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ABSTRACT

This Missouri Vocational Instruction Management System instructor's drafting guide has been keyed to the drafting competency profile developed by state industry and education professionals. The guide contains a cross-reference table of instructional materials. Two units are included: (1) orthographic drawings and (2) dimensioning. Each unit contains the following: (1) unit and specific objectives; (2) suggested activities; (3) instructional materials; (4) unit content; (5) references; (6) instructor notes; (7) information sheets; (8) lessons; (9) transparency masters; (10) handouts; (11) assignment sheets; (12) job sheets; and (13) unit test and answers. (NLA)

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Module

3 ORTHOGRAPHIC DRAWINGS & DIMENSIONING

70-4003-I
Instructor's Guide

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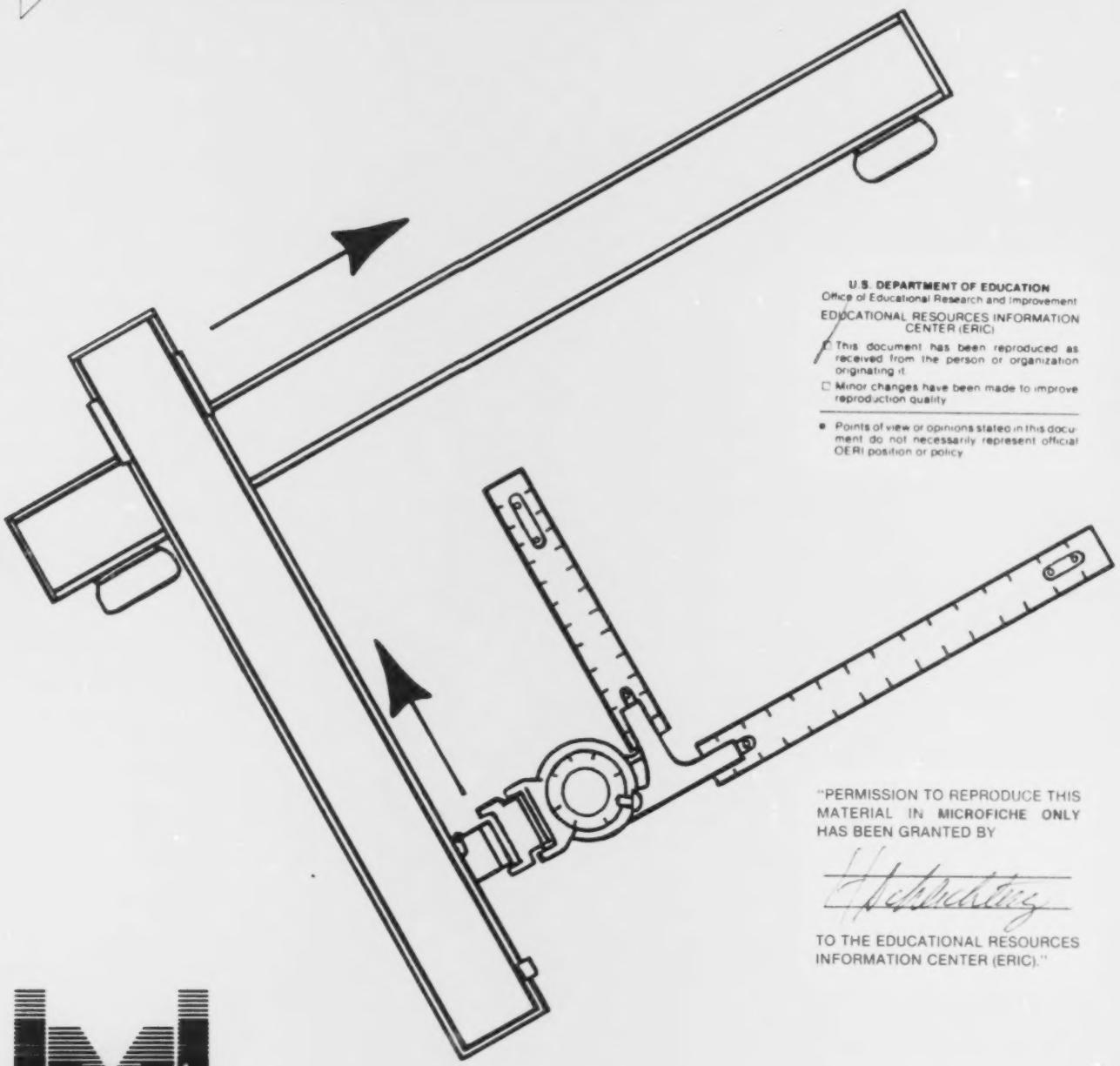

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DRAFTING

Module 3: Orthographic Drawings and Dimensioning

Instructional Materials Laboratory
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University of Missouri-Columbia
Columbia, MO 65211

1991

Instructor's Guide
Catalog N. 70-4003-I

FORWARD

Once again, we are indebted to the teachers and administrators who provided their time, effort and professionalism to develop curriculum guides for trade, technical and industrial education programs. This drafting guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignments sheets and test items are keyed to specific competencies. A cross-reference table has been included to identify quickly the parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future drafting curriculum modifications will begin with this guide. The drafting field is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding ares for improvement are both encouraged and appreciated.

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ACKNOWLEDGEMENTS

This drafting guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the drafting competency profile developed by industry and education professionals in the state.

When searching for current drafting materials to adopt or use in the guide's development, comparable materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which Missouri is a member. MAVCC materials, therefore, have been relied upon as a resource for this guide. A debt of thanks is owed to the entire MAVCC organization for the research and development of these drafting materials.

Special appreciation is given to the writers for their self-motivation, reliability and technical expertise.

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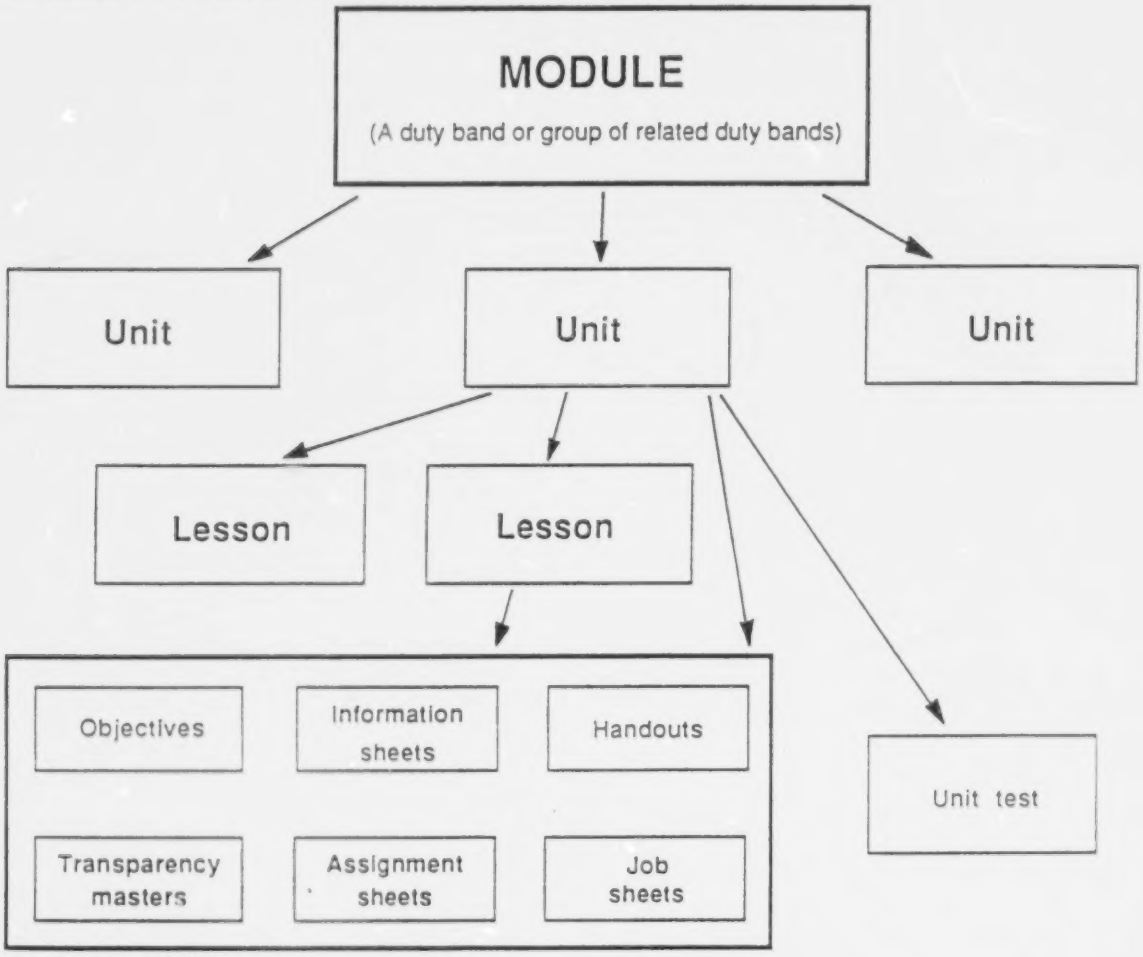
HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Drafting guide contains ten modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc., are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

3 = **Mastery** - can work independently with no supervision
2 = **Requires supervision** - can perform job completely with limited supervision
1 = **Not mastered** - requires instruction and close supervision
N = **No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, etc. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives that state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc., are included in the Notes to the Instructor section.

Information sheets (color-coded green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage, while **WARNING** statements recommend procedures to avoid bodily injury. Handouts and transparency masters are noted in the information sheets for instructional use.

Transparency masters (color-coded white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary, and they direct students to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion.

Handouts (color-coded white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (color-coded tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (color-coded blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance that might be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (color-coded yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), using Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson by lesson.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

Drafting

Module: Orthographic Drawings and Dimensioning

Cross-Reference Table of Instructional Materials

Competency	Unit	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
E 1	I	1.1-1.16	2-21	2-16			1-41	
E 2	I	1.17	1-21	1-16	8, 9			
E 3	I	1.17	1-21	1-16	3-7, 10-14		42	
E 4	I	1.1 - 1.16					1-41	
E 5	I	1.1 - 1.16	1	1			39-41	
H 1	II	1.19 - 1.29			1-13			
H 2	II	1.7	4, 5				27-30	
H 3	II	1.1 - 1.18	1-22				1-74	

MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT I: ORTHOGRAPHIC VIEWS

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify planes and lines, and construct missing hidden and visible lines, various views, and points, planes, and lines in orthographic views. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring ___ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1.1 Match terms related to orthographic views with their correct definitions.

1.2 Distinguish between the types of projection systems.

1.3 Identify the ISO projection symbols.

1.4 Arrange in order the steps in visualizing an orthographic projection.

1.5 List the six views possible in orthographic projection.

1.6 List the three most commonly used views in orthographic projection.

1.7 Select true statements concerning the steps in selecting correct views of an object.

1.8 List the basic dimensions of an object.

1.9 List the common methods of transferring dimensions.

1.10 Select the projection of lines in orthographic views.

1.11 Identify types of planes.

1.12 Select the correct use of hidden lines.

1.13 Identify the use of center lines.

1.14 Select correct line precedence in an orthographic drawing.

1.15 Identify line thicknesses used in orthographic drawings.

1.16 State the purpose of runouts.

1.17 Demonstrate the ability to:

a. Identify types of planes in orthographic views.

b. Identify projection of lines in orthographic views.

c. Construct a top view.

d. Construct a front view.

e. Construct a right-side view.

f. Construct missing hidden lines.

g. Construct missing visible and hidden lines.

h. Make a two-view sketch.

i. Make a three-view sketch.

j. Identify drawing layout procedures for a one-view drawing.

k. Identify drawing layout procedures for a two-view drawing.

l. Identify drawing layout procedures for a three-view drawing.

m. Construct a runout.

n. Construct a point in an orthographic view.

o. Construct a line in an orthographic view.

p. Construct a plane in an orthographic view.

1.18 Construct various orthographic drawings.

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: ORTHOGRAPHIC PROJECTION AND VIEWS

a. Information outline

b. Handouts

HO 1.1: First- and Third-Angle Projection
HO 1.2: Orthographic Projection
HO 1.3: Orthographic Projection Continued
HO 1.4: Principal Views in Orthographic Projection
HO 1.5: One and Two-View Drawings
HO 1.6: Three-View Drawings and Positioning of Views
HO 1.7: Position of Side View
HO 1.8: Methods of Transferring Dimensions
HO 1.9: Projection of Lines in Orthographics
HO 1.10: Planes in Orthographic Projection
HO 1.11: Usage of Hidden Lines
HO 1.12: Usage of Center Lines
HO 1.13: Line Precedence
HO 1.14: Line Thickness in Orthographic Drawing
HO 1.15: Fillets, Rounds, and Runouts
HO 1.16: Projection of Fillet and Round Edges

c. Transparency masters

TM 1.1: Comparison Between First- and Third-Angle Projection
TM 1.2: Orthographic Projection
TM 1.3: Orthographic Projection (Continued)
TM 1.4: Orthographic Projection (Continued)
TM 1.5: Orthographic Projection (Continued)
TM 1.6: Principal Views in Orthographic Projection
TM 1.7: One-View Drawings
TM 1.8: Two-View Drawings
TM 1.9: Three-View Drawings
TM 1.10: Positioning of Views
TM 1.11: Position of Side View
TM 1.12: Methods of Transferring Dimensions
TM 1.13: Visualization of a Point
TM 1.14: Visualization of Lines
TM 1.15: Projection of Lines in Orthographics
TM 1.16: Visualization of Planes
TM 1.17: Planes in Orthographic Projection
TM 1.18: Usage of Hidden Lines
TM 1.19: Usage of Center Lines
TM 1.20: Line Precedence
TM 1.21: Line Thickness in Orthographic Drawing

TM 1.22: Fillets, Rounds, and Runouts
TM 1.23: Projection of Fillet and Round Edges

d. Assignment sheets

AS 1.1: Identify Types of Planes in Orthographic Views
AS 1.2: Identify Projection of Lines in Orthographic Views
AS 1.3: Construct a Top View
AS 1.4: Construct a Front View
AS 1.5: Construct a Right-Side View
AS 1.6: Construct Missing Hidden Lines
AS 1.7: Construct Missing Visible and Hidden Lines
AS 1.8: Make a Two-View Sketch
AS 1.9: Make a Three-View Sketch
AS 1.10: Construct an Orthographic Drawing
AS 1.11: Construct a Runout
AS 1.12: Construct a Point in an Orthographic View
AS 1.13: Construct a Line in an Orthographic View
AS 1.14: Construct a Plane in an Orthographic View

E. Answers to assignment sheets

F. Unit test

G. Answers to unit test

REFERENCES

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5. Jensen, Cecil and Jay Helsel. Engineering Drawing and Design. New York: Gregg Division/McGraw-Hill Book Co., 1979.

6. Spence, William P. Drafting Technology and Practice. Revised ed. Pittsburg, Kan. 66762: Bennett and McKnight Publishing Co., 1980.

7. Wallach, Paul Ross. Drafting Problems, 2nd ed. Mission Hills, Calif. 91345: Glencoe Publishing Company, 1988.

8. Wallach, Paul Ross and Dean Chowenhill. Drafting in a Computer Age. Albany, N. Y. Delmar Publishers, Inc., 1989.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Construct a model in a "Glass box" and discuss orthographic projection.
2. Use blocks to show various angles and use blocks for sketching.
3. Construct blocks, if necessary.
4. Assignment sheets suggest the use of vellum. Other media may be substituted.
5. Use drawings from industry and finished products as examples.

MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT I: ORTHOGRAPHIC VIEWS

LESSON 1: ORTHOGRAPHIC PROJECTION AND VIEWS

I. Terms and definitions

A. **Coincide**--to match up identically

B. **Depth**--distance from front to back plane

C. **Fillet**--small, rounded inside corner of an object

NOTE: Fillets and rounds are normally 1/4" radius or less.

D. **First-angle projection**--all views are projected onto planes located behind the object (HO 1.1)

E. **Fold line**--a theoretical line between two views where viewing planes fold

NOTE: This is used as a reference line on drawings.

F. **Foreshortened**--to appear shorter to the eye than it actually is

G. **Frontal view**--front view

H. **Height**--distance from bottom to top plane

I. **Horizontal view**--top view

J. **Inclined plane**--a plane that is foreshortened in two principal viewing planes and an edge view in one other principal viewing plane

K. **Width**--distance from left side to right side plane

L. **Line of sight**--direction from which an object is being viewed

M. **Line precedence**--lines that are more important to show than others

N. **Line**--straight element that is generated by a moving point and has extension only along the path of the point

O. **Normal plane**--true size plane that is parallel to one principal viewing plane and edge view in other two principal planes

P. **Oblique plane**--a plane that is foreshortened in all three principal viewing planes

Q. **Orthographic projection**--method or representing the exact shape of an object in two or more views on planes at right angles to each other

R. **Profile view**--left side or right side view

S. **Projection lines**--lines used to extend from one view to the next view

T. **Round**--small rounded outside corner of an object

U. **Runout**--intersection of a fillet or round with another surface

V. **Skew (oblique) lines**--nonintersecting lines, not parallel to each other or to the principal views

W. **Third-angle projection**--all views are projected onto planes lying between the object and viewer (HO 1.1)

X. **Transfer**--take from one point of view and put in another view

Y. **True size**--a surface or line that is shown in its actual size

Z. **Visualize**--to form a mental picture or image

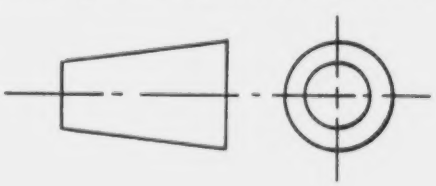
II. Types of projection systems (TM 1.1)

A. **First-angle**--Used in European and Asian Countries

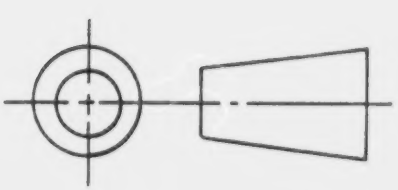
B. **Third-angle**--Used in the United States, Canada, and other countries

III. ISO (International Standards Organization) projection symbols (TM 1.1)

A. First-angle



B. Third-angle



NOTE: Location of symbol is in lower right-hand corner of drawing and adjacent to title block.

IV. Steps in visualizing an orthographic projection (HO 1.1-1.4, TM 1.1-1.6)

A. Visualize by looking at the actual object or picture of the object

B. To obtain views, project the lines of sight to each plane of projection from all points on the object

C. Rotate all planes until they align with front plane of projection

D. Visualize the six possible views of the object that are revolved into the same plane as on a drawing surface

E. Inspect views and determine those needed to adequately represent the object

V. Views possible in orthographic projection (HO 1.4, TM 1.4)

A. Top
B. Front
C. Right side
D. Left side
E. Bottom
F. Rear

VI. Most commonly used views in orthographic projection (HO 1.3, TM 1.5)

A. Top B. Front C. Right side

VII. Steps in selecting correct views of an object (TM 1.6-1.11, (HO 1.4-1.7)

A. Select view necessary to best describe contour shape in front view
B. Select the view that contains the least number of hidden lines
C. Select alternate position for right side view if drawing area is crowded
D. Select only views necessary to present an understanding of an object
E. If there is no other option, select the view that best describes the object
F. Select view positions to avoid crowding of dimensions and notes

VIII. Basic dimensions of an object (HO 1.2 and HO 1.4, TM 1.2 and 1.6)

A. Width B. Height C. Depth

IX. Most common methods of transferring dimensions (HO 1.8, TM 1.12)

A. 45° mitre line

NOTE: This is used for projecting depth dimensions.

B. Dividers
C. Scale

X. Projection of lines in orthographic views (HO 1.9, TM 1.14, 1.15)

A. Point B. True length C. Foreshortened

XI. Types of planes (HO 1.10, TM 1.16, 1.17)

A. Normal
B. Inclined

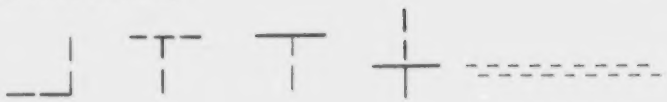
NOTE: True size is determined by auxiliary views.

C. Oblique

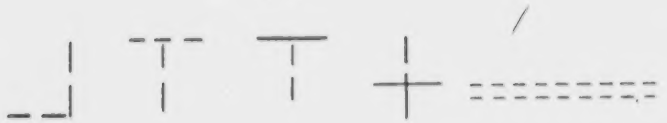
NOTE: True size is determined by auxiliary views.

XII. Use of hidden lines (HO 1.11, TM 1.18)

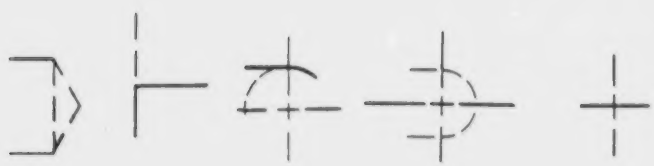
A. Correct



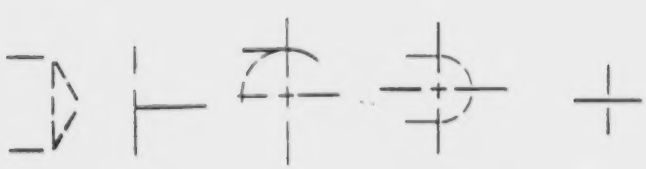
B. Incorrect



C. Correct



D. Incorrect



XIII. Use of center lines (HO 1.12, TM 1.19)

A. Center lines are used to locate the centers of symmetrical objects and paths of motion.

B. Center lines are drawn as a series of long and short dashes.

XIV. Line precedence in an orthographic drawing (HO 1.13 and TM 1.20)

A. Visible line

B. Hidden line

C. Cutting plane line

D. Center line

XV. Line thicknesses used in orthographic drawings (HO 1.14, TM 1.21)

A. Visible line-- (thick)

B. Hidden line-- (thin)

C. Center line-- (thin)

D. Phantom line-- (thin)

XVI. Purpose of runouts--Intersection of fillets and rounds are used to eliminate problems in castings (HO 1.15, 1.16, TM 1.22, 1.23)

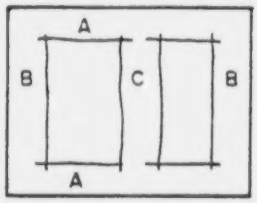
XVII. Making a two-view sketch

Premise: A two-view sketch can be made by using the procedure in the following example.

Example:

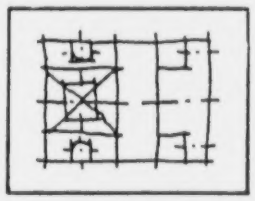
1. Sketch the horizontal lines to locate the height of the object

   NOTE: The distance at the top and bottom of the paper should be the same.

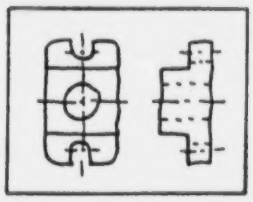


2. Sketch the vertical lines to locate the width and depth of the object

   NOTE: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space.



3. Block in details and, using diagonals to locate centers, and lightly sketch the circles and arcs



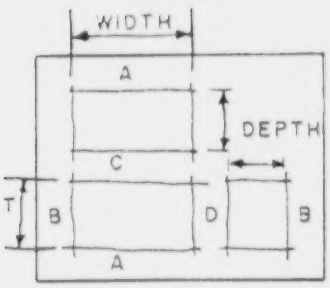
4. Use an artgum eraser to dim construction lines and darken in visible lines

XVIII. Making a three-view sketch

Example:

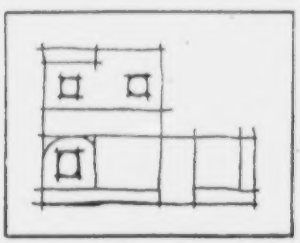
1. Sketch the horizontal lines to locate the height of the object

   NOTE: The distance at the top and bottom of the paper should be the same. The distance between the top and front views can be the same as that on the top and bottom or slightly less than that space.



2. Sketch the vertical lines to locate the width and depth of the object

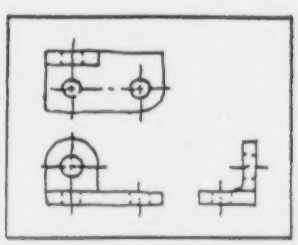
   NOTE: The distance at the left side and right side of the paper should be the same. The distance between the views can be the same as that on the left side and right side or slightly less than that space. In the top and side views, the depth must be equal; this can be done by marking a piece of paper with depth.



3. Block in details using diagonals to locate centers, if necessary, and lightly sketch the circles and arcs

4. Add line features to the views of the object

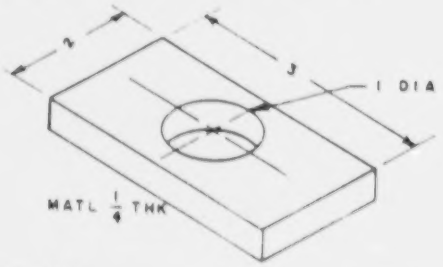
5. Use an artgum eraser to dim construction lines and darken visible lines



XIX. Drawing layout procedures for a one-view drawing

Premise: It is important for good appearance that views be well balanced on drawing media, whether the drawing shows one, two, three views, or more. Use the procedure in the following example for spacing a one-view drawing.

Example:



1. Locate the center of the working space by constructing diagonals (Figure 1)

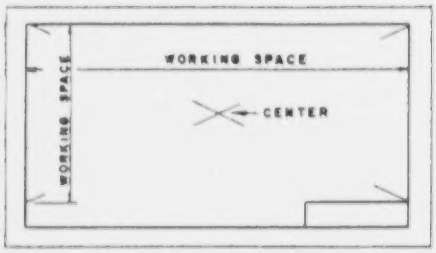


FIGURE 1

2. Block in horizontal construction lines by measuring the distances (Figure 2)

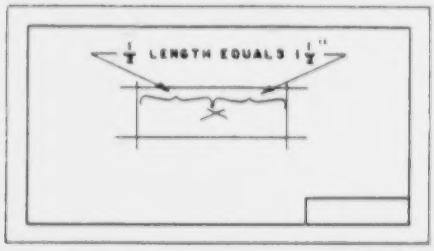


FIGURE 2

3. Block in vertical construction lines by measuring the distances (Figure 3)

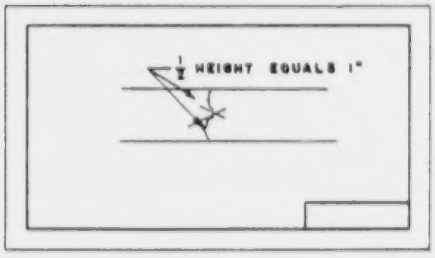


FIGURE 3

4. Construct the necessary center lines, circles, arcs and then straight lines (Figure 4)

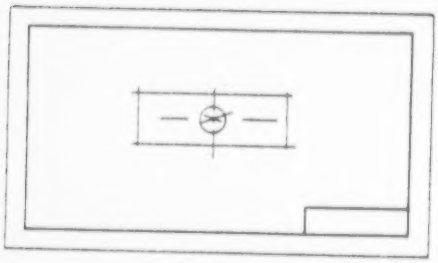


FIGURE 4

5. Erase construction lines not needed (Figure 5)

6. Darken circles and arcs first, then straight lines (Figure 5)

7. Fill in title block

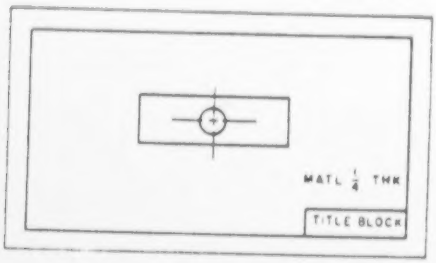


FIGURE 5

XX. Drawing layout procedures for a two-view drawing

Premise: It is important for good appearance that views be well balanced on drawing media. The drafter must determine the size of the object to be drawn, number of views, scale used and space between views. Space between views should be allotted for notes and dimensions. Use the procedure in the following example for allotted space for a two-view drawing.

Example:

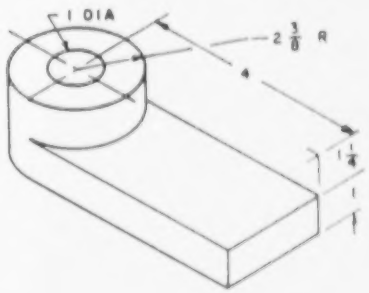
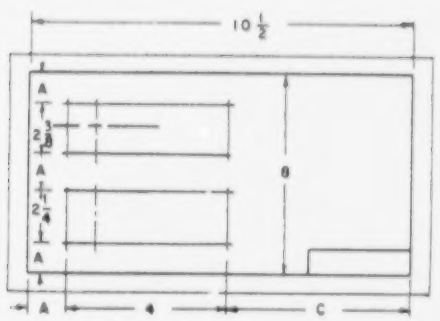


FIGURE 1

1. Calculate the spacing of views for object shown in Figure 1 (Figure 2)

   NOTE: Spacing is assumed between views when drawing is dimensioned.



$$2\tfrac{3}{8} + 2\tfrac{1}{4} + A + 4\tfrac{3}{8} \qquad B - 4\tfrac{3}{8} = 3\tfrac{3}{8} \div 3 = 1\tfrac{1}{8} = A$$

FIGURE 2

2. Block in views with light horizontal and vertical construction lines through spacing marks (Figure 2)

$$4 + 1\tfrac{1}{8} + 8\tfrac{1}{8} \qquad 10\tfrac{1}{2} - 5\tfrac{1}{8} = 5\tfrac{3}{8} = C$$

3. Locate center lines, and then construct light arcs and circles (Figure 2 and 3)

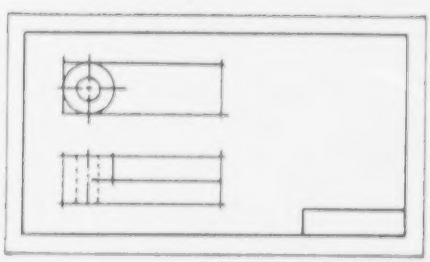


FIGURE 3

4. Add light visible and hidden lines (Figure 3)

   NOTE: Do not complete one view before starting on another.

5. Erase unnecessary construction lines, and then darken in circles, hidden lines, and visible lines (Figure 4)

NOTE: Hidden and center lines should be thin in contrast to the visible lines, but should be dark enough to reproduce well.

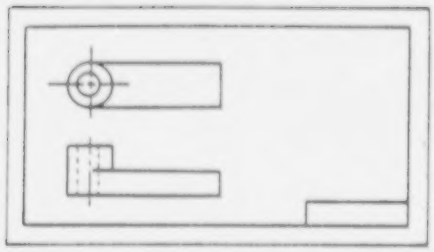


FIGURE 4

6. Letter in title block

XXI. Drawing layout procedures for a three-view drawing

Premise: A drafter should space views so that they will give the drawing a balanced appearance. Before drawing an object, the number of views needed must be decided and a three-view drawing is sometimes required. To construct a three-view drawing use the procedure in the following example.

Example:

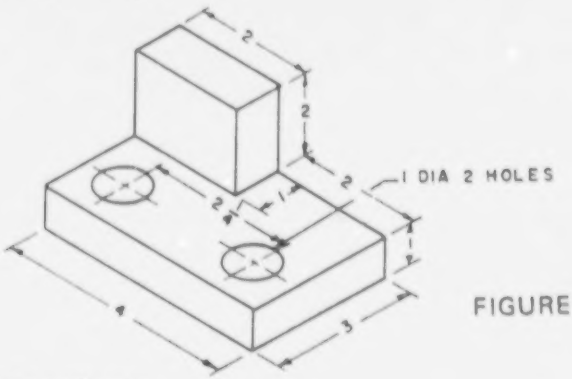


FIGURE 1

1. Select the proper surface to represent the front view for object shown in Figure 1

2. Construct a three-view sketch to determine dimension for blocking in and to clear up any uncertain details

3. Select a sheet size and scale that will avoid crowding of views, dimensions, and notes

NOTE: For this procedure the scale, dimensions, notes, and title block are omitted.

4. Calculate the spacing of the views for a standard drawing sheet (Figure 2)

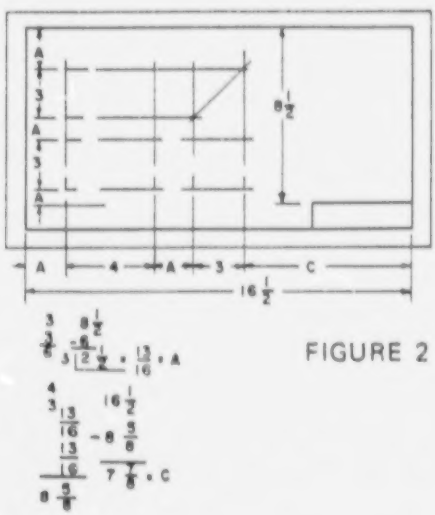


FIGURE 2

5. Block in views with light horizontal and vertical construction lines through spacing marks (Figure 3)

   NOTE: Check measurements carefully when blocking in views.

6. Construct mitre line for transferring of measurements in top and right side views (Figure 3)

7. Locate center lines and construct light arcs and circles, straight visible lines, and hidden lines (Figure 4)

   NOTE: Check layout carefully for missing lines, notes, or special shapes required.

8. Erase unnecessary construction lines and give drawing a good cleaning (Figure 5)

9. Darken in arcs and circles, and then center lines, hidden lines, and visible lines (Figure 5)

10. Letter notes and title block

11. Check finished drawing carefully for spelling, line weight, and general appearance

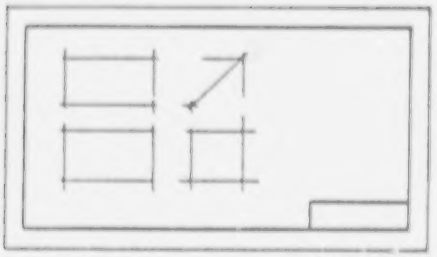


FIGURE 3

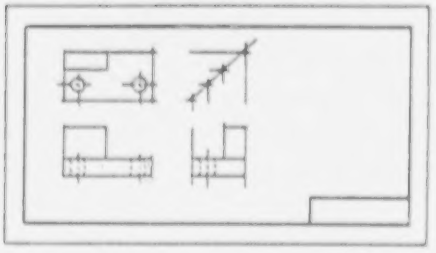


FIGURE 4

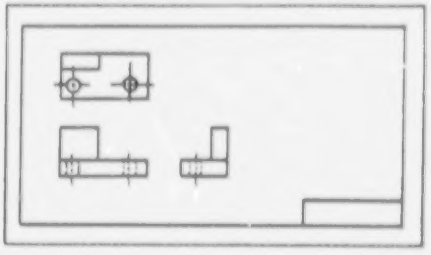
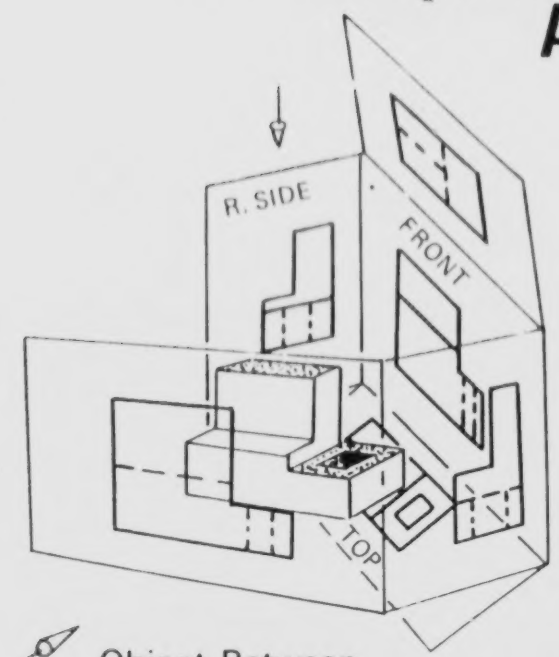
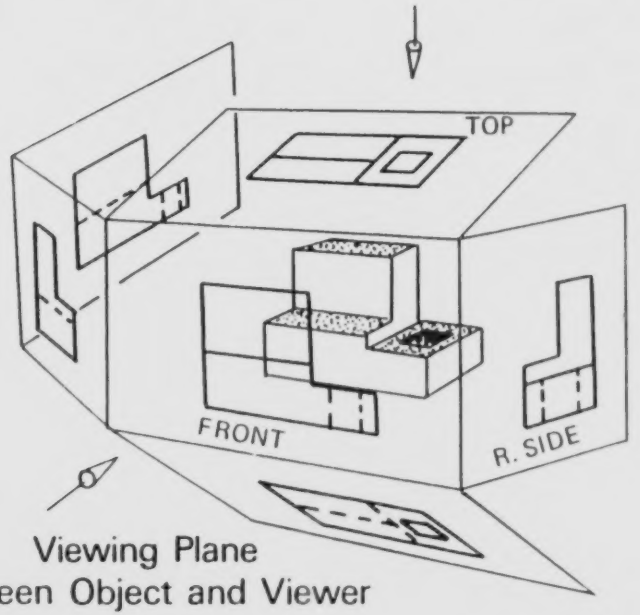


FIGURE 5

Comparison Between First and Third Angle Projection

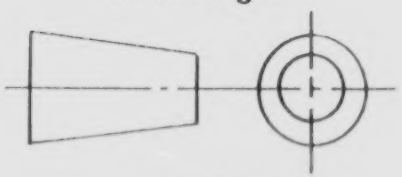


Object Between
Plane and Viewer



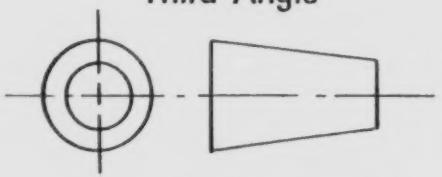
Viewing Plane
Between Object and Viewer

First Angle



Symbol

Third Angle

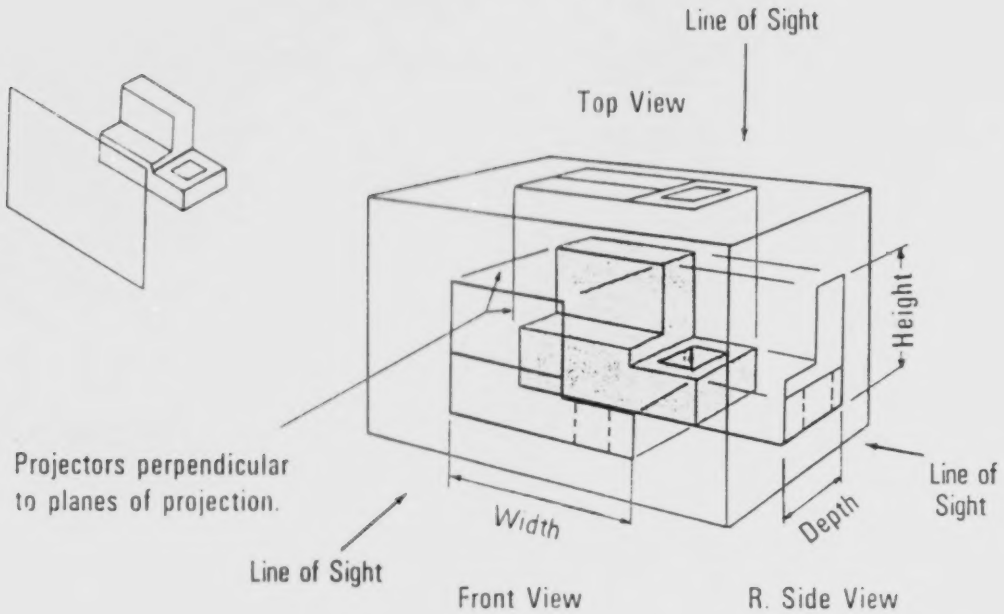


Symbol

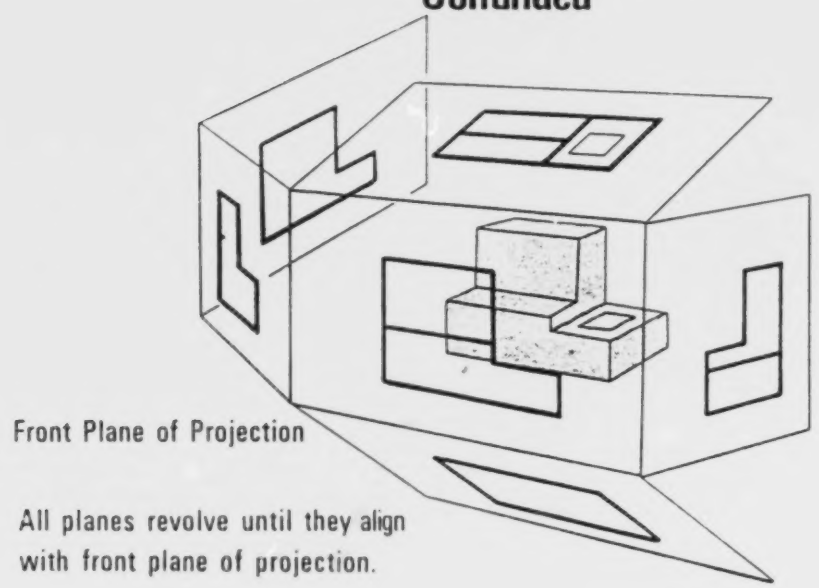
HO 1.1

Orthographic Projection

HO 1.2

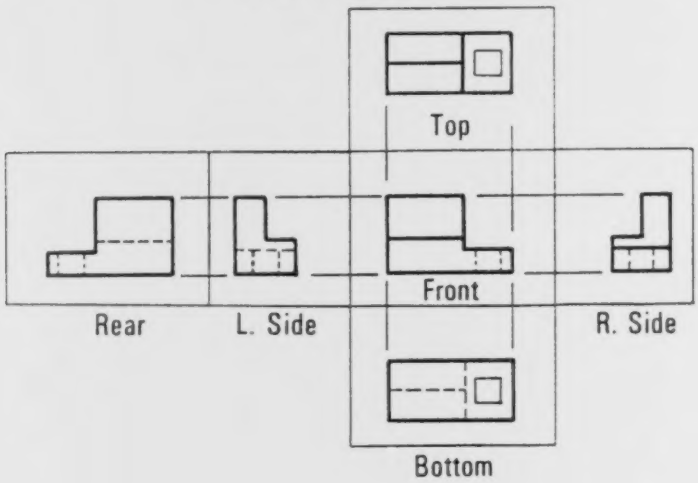


Orthographic Projection Continued



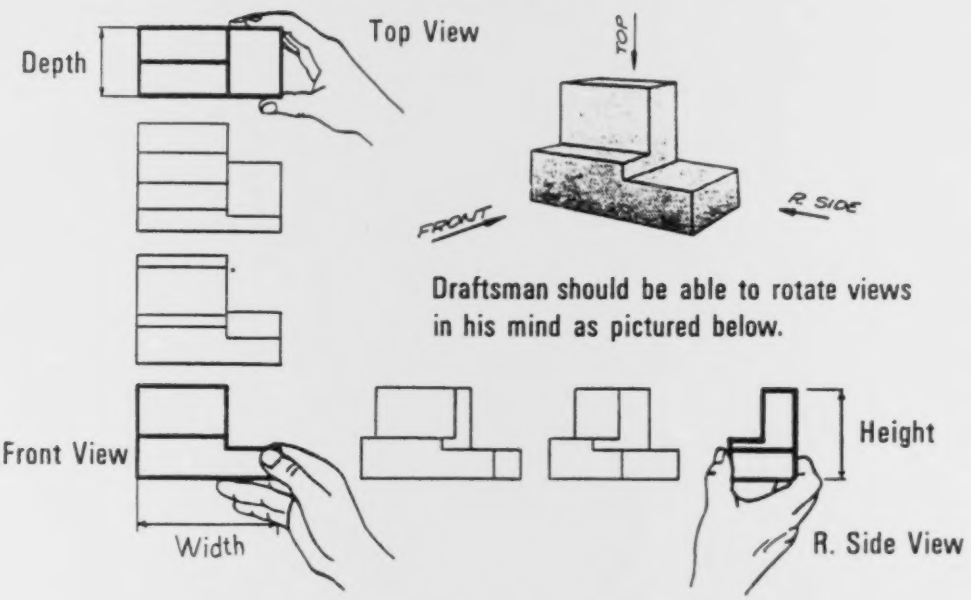
All planes revolve until they align with front plane of projection.

Orthographic Projection Continued

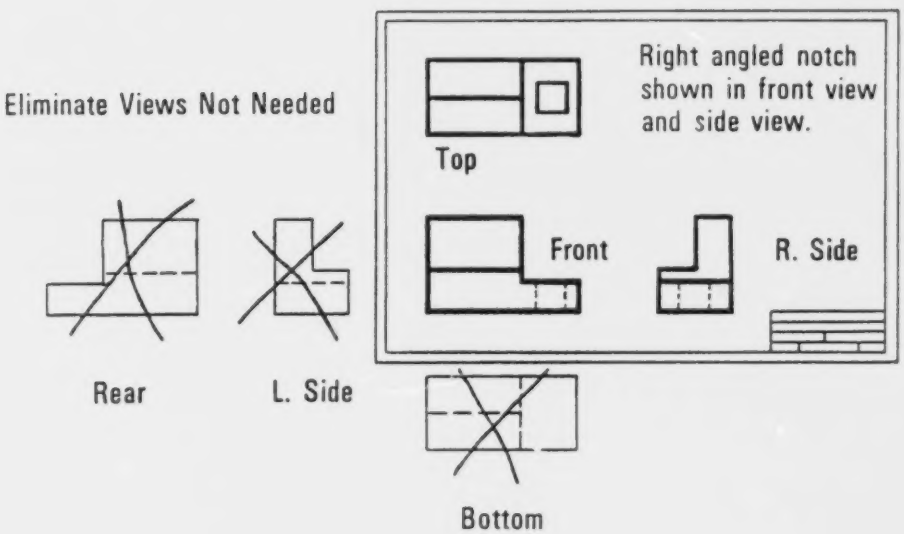


The six planes are layed on a flat plane as on a drawing surface.

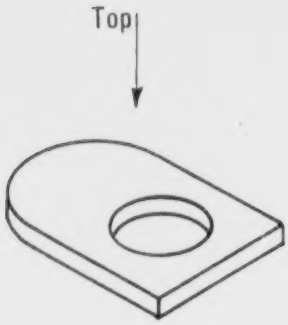
Orthographic Projection Continued



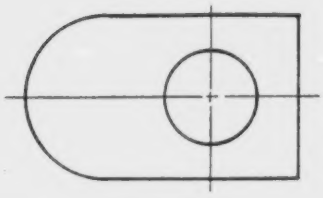
Principal Views in Orthographic Projection



One-View Drawings

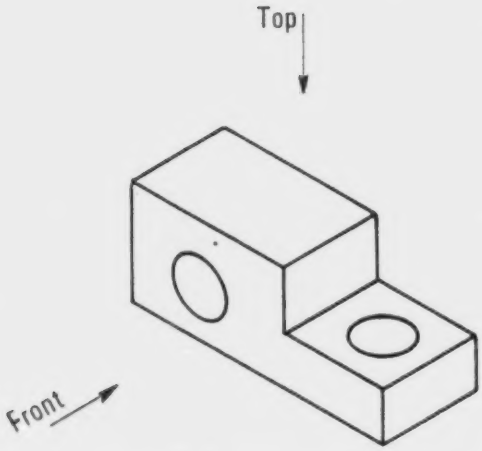


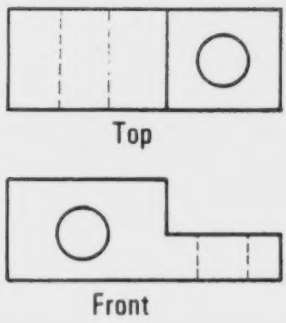
Objects with very little thickness require only one view.



Top View

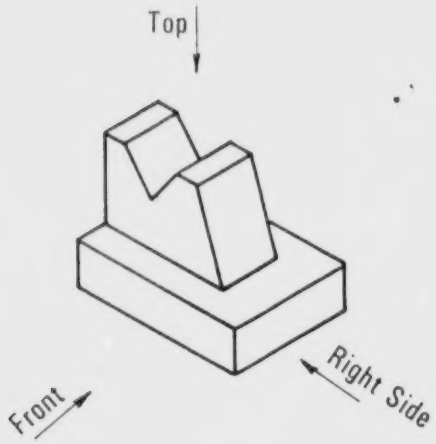
Two-View Drawings



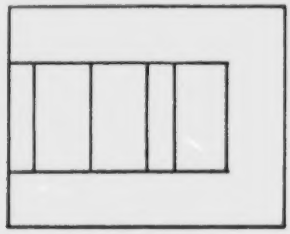


Some objects require only two views.

Three-View Drawings

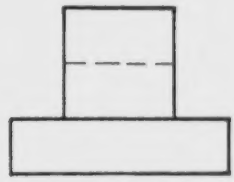


Some objects require three views to describe their shape.



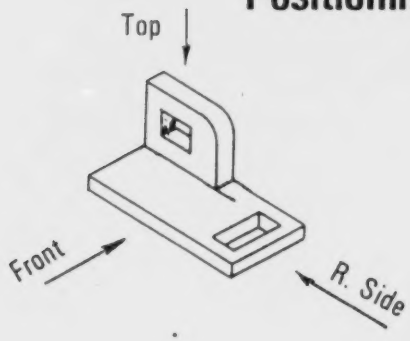
Top View

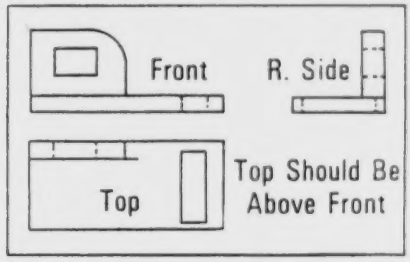
Front



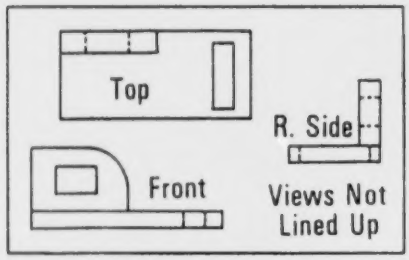
Right Side

Positioning of Views

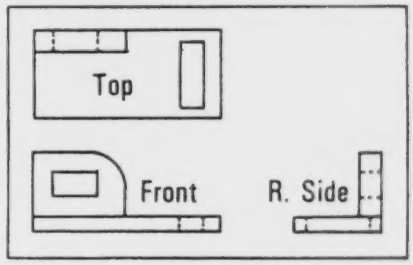




INCORRECT

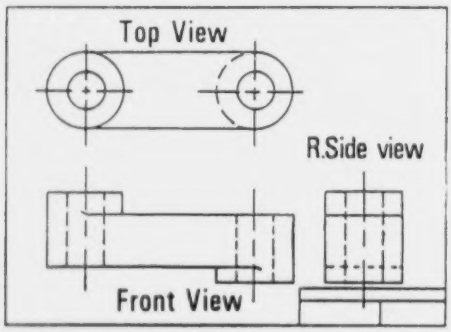


INCORRECT



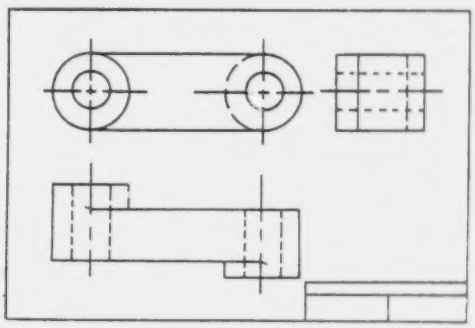
CORRECT

Position of Side View



NORMAL LOCATION

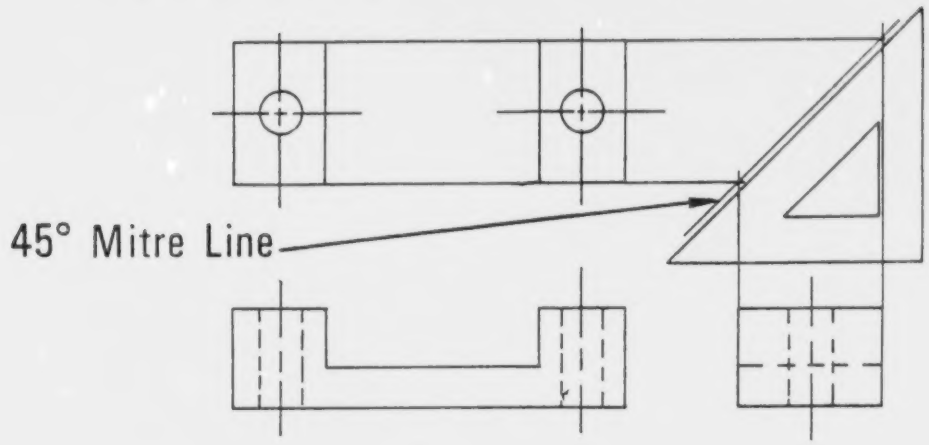
- Shape of object determines best location for side view.
- R. Side view can be projected off the front view or the top view.
- Space limitation requires alternate location.

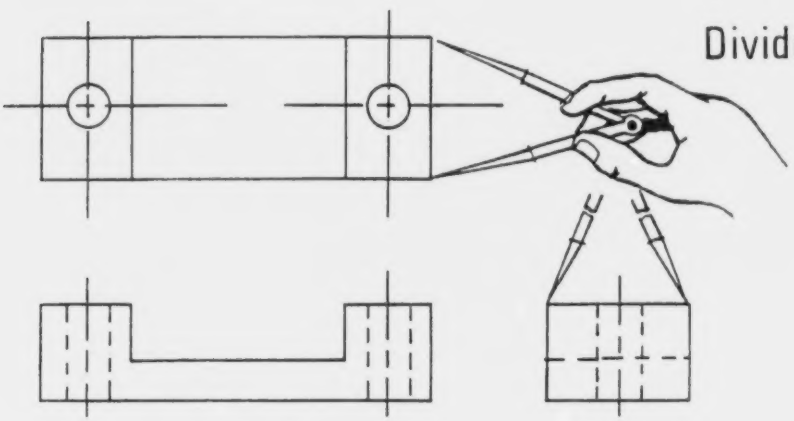


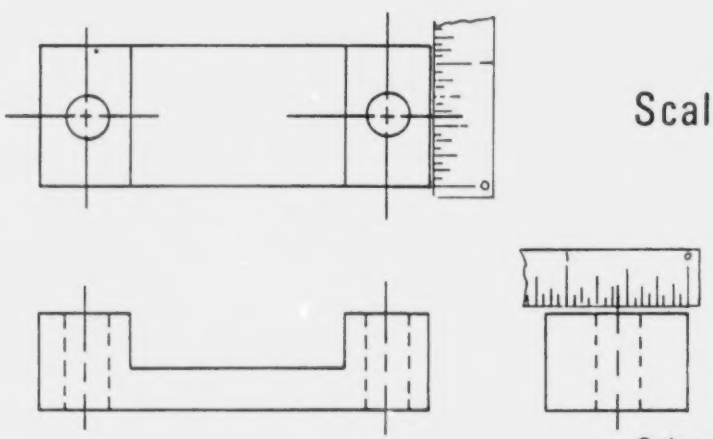
ALTERNATE LOCATION

HO 1.8

Methods of Transferring Dimensions

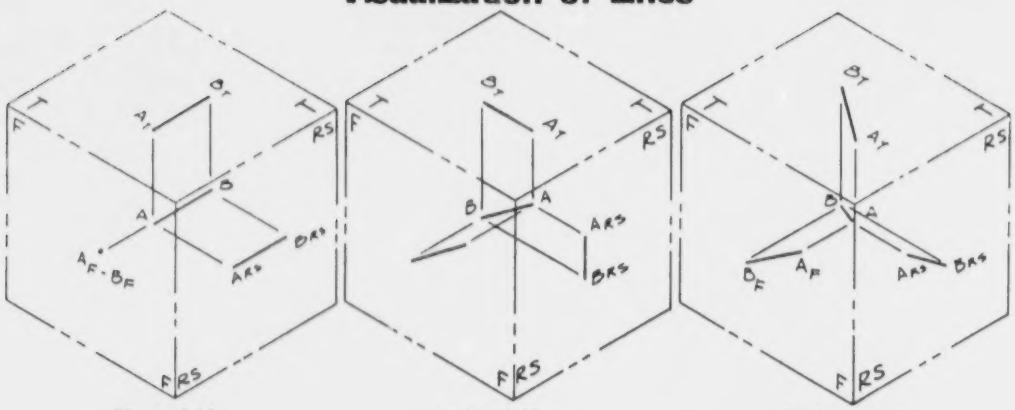


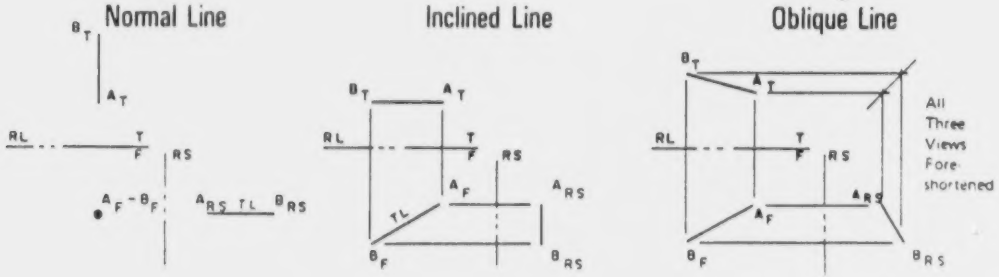




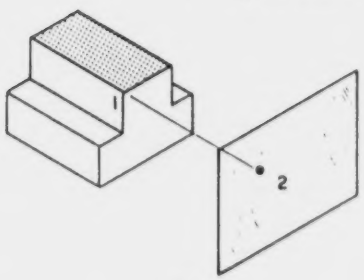
HO 1.9

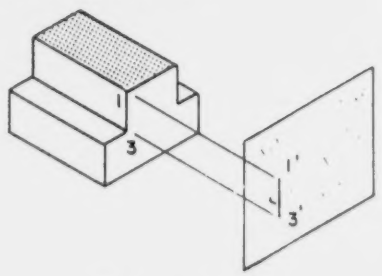
Visualization of Lines

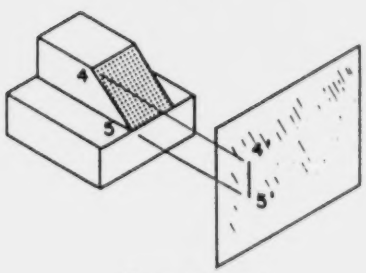


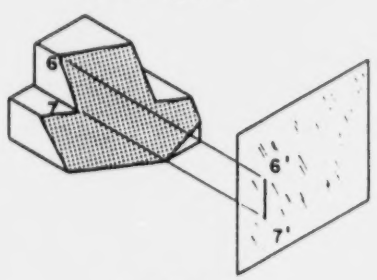


Projection of Lines in Orthographics



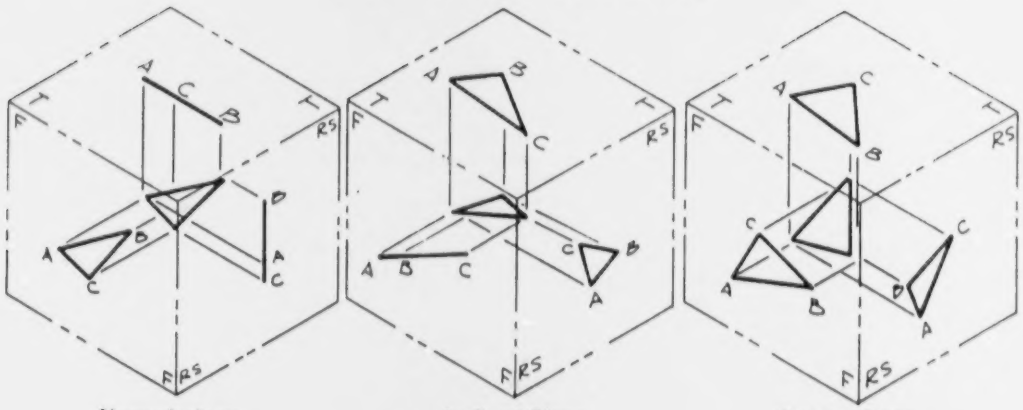




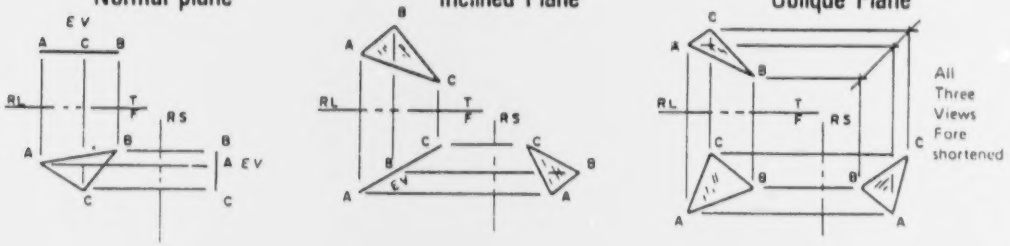


Visualization of Planes

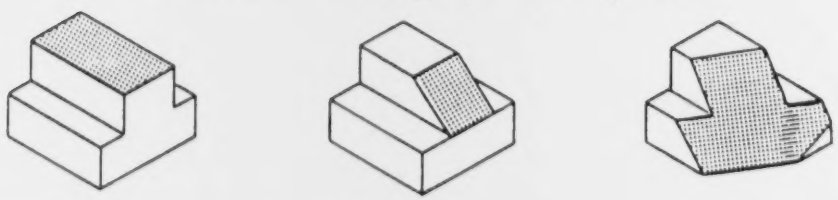
HO 1.10

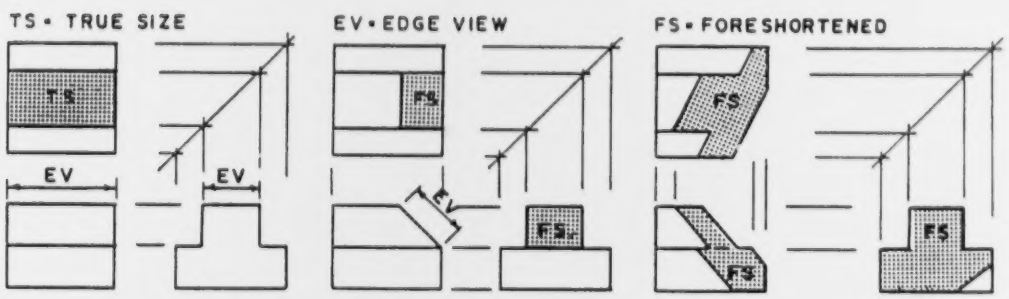


Normal plane | Inclined Plane | Oblique Plane



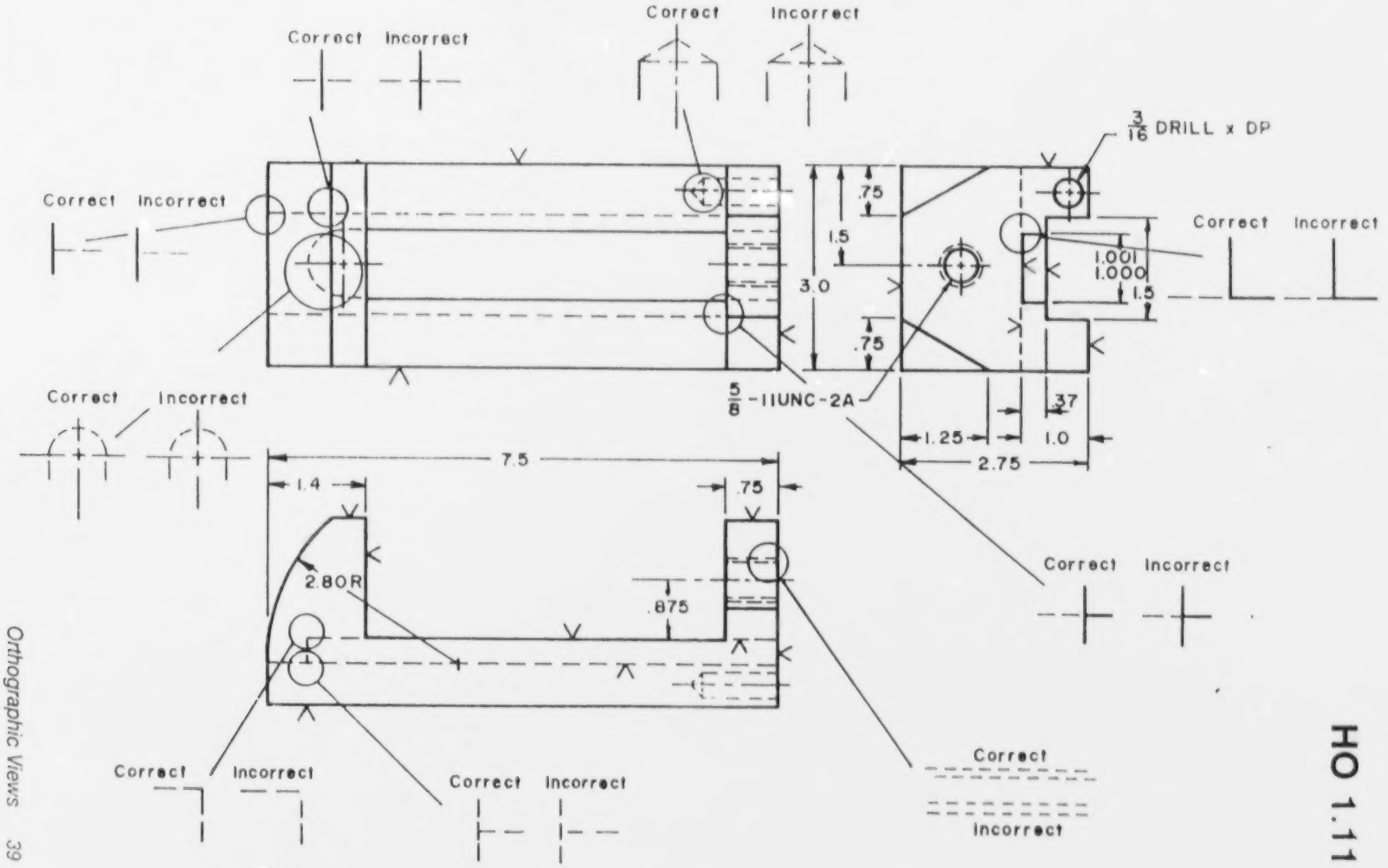
Planes in Orthographic Projection





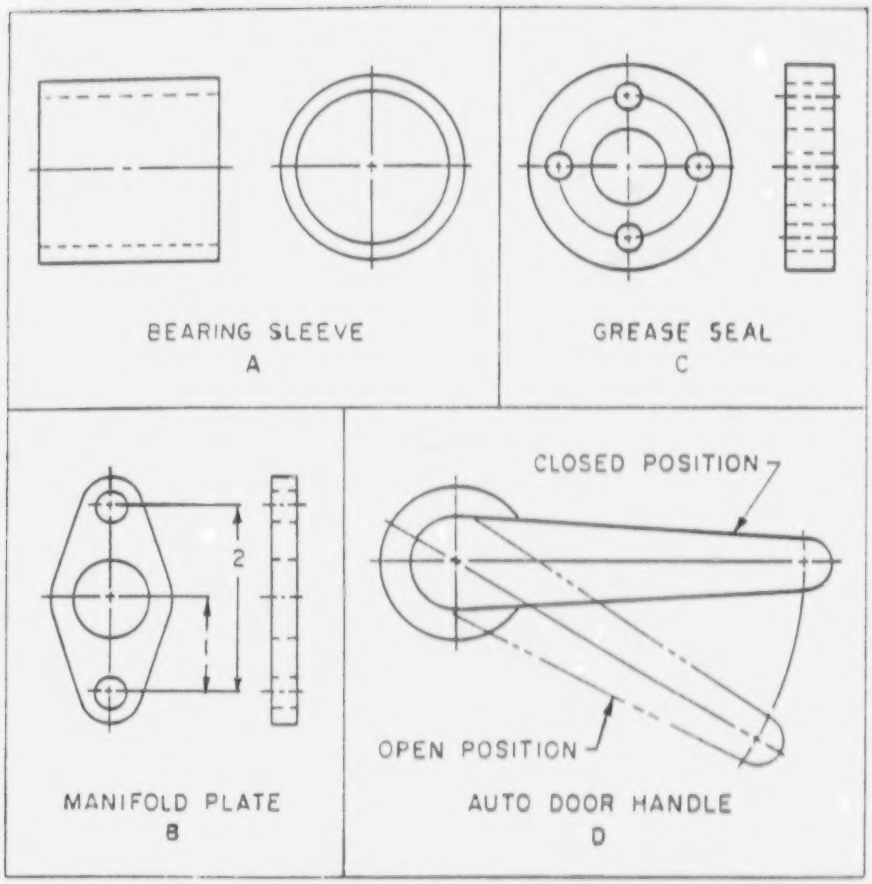
Normal | Inclined | Oblique

Usage of Hidden Lines



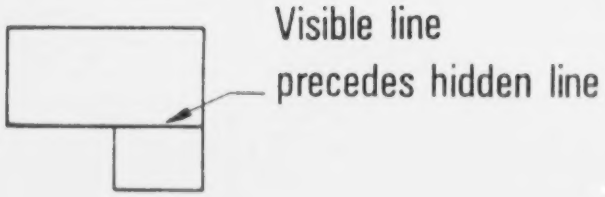
HO 1.11

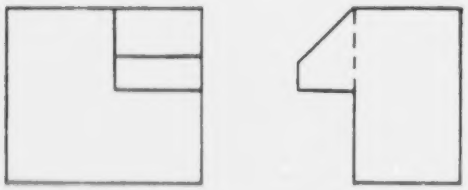
Usage of Center Lines

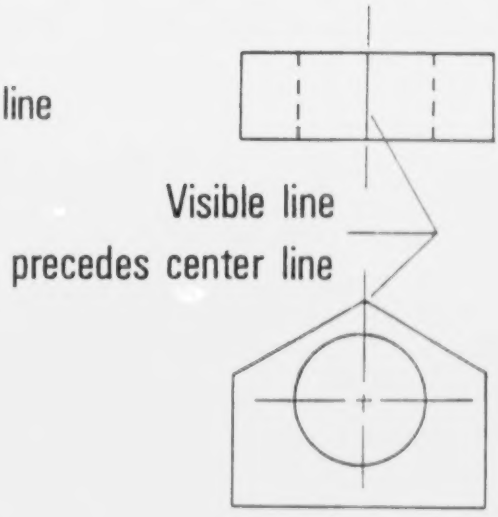


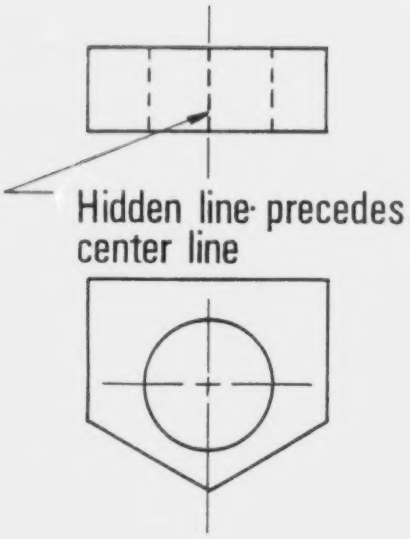
(From William Spence, Drafting Technology & Practice, p. 106)

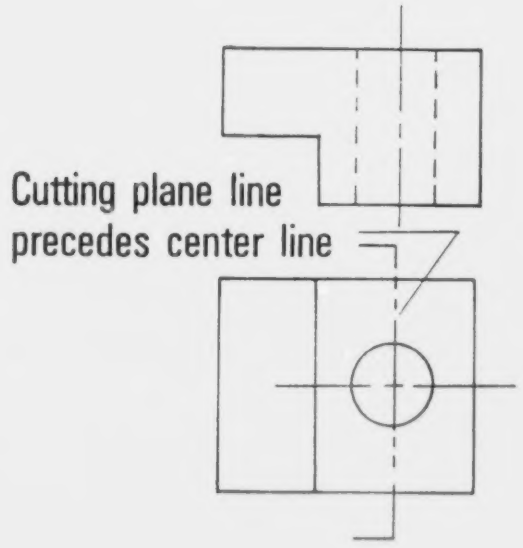
Line Precedence



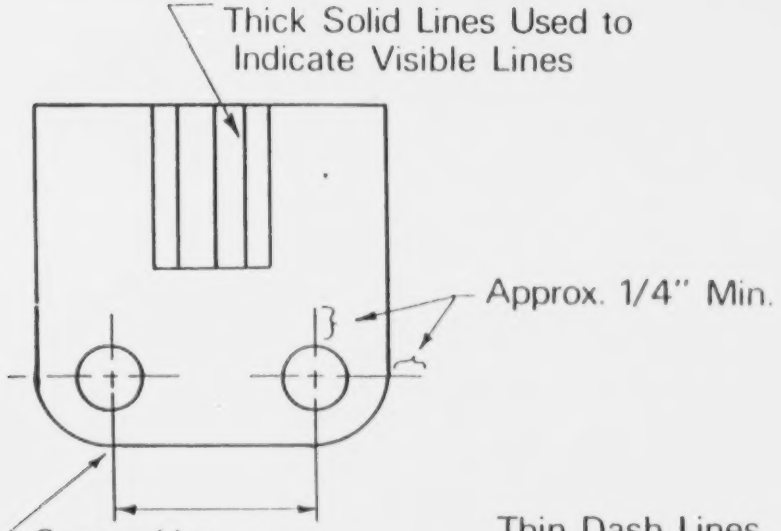


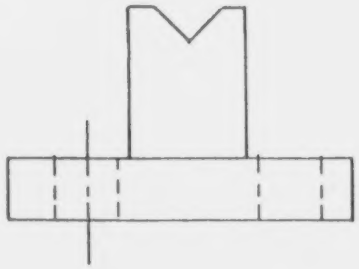


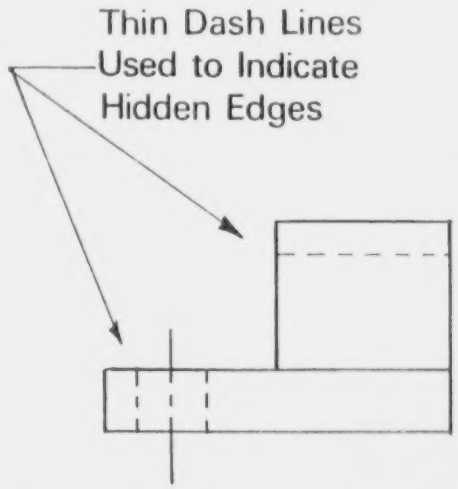


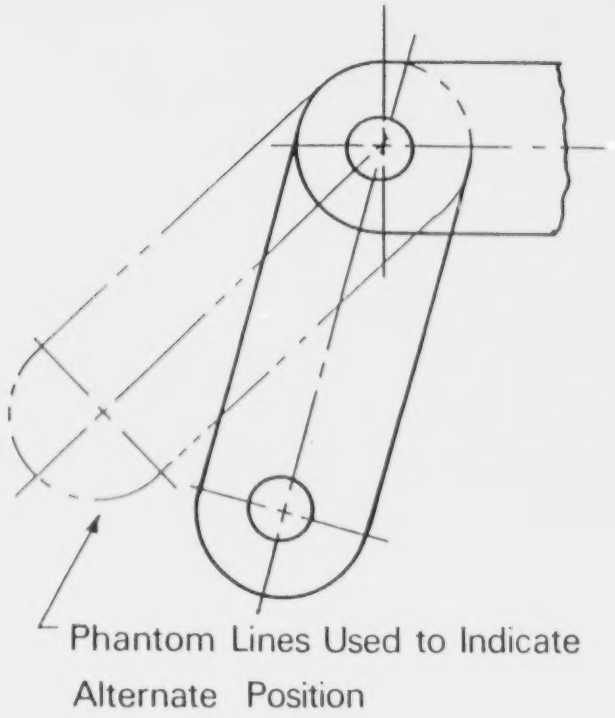


Line Thickness in Orthographic Drawing



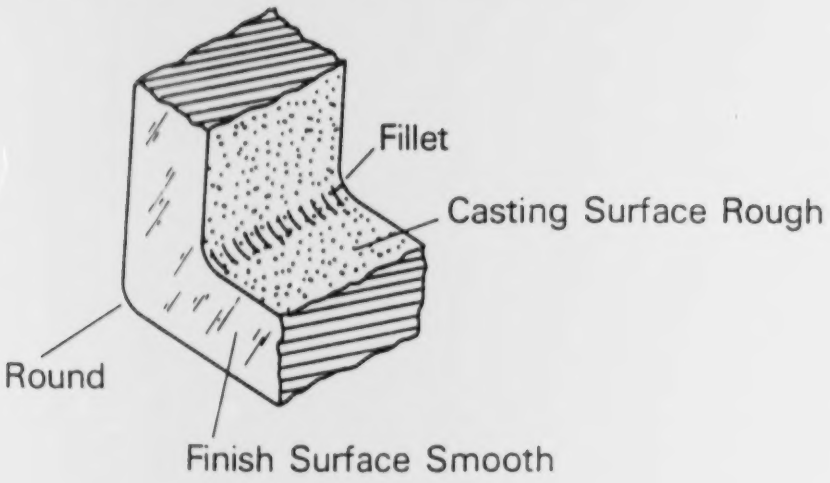


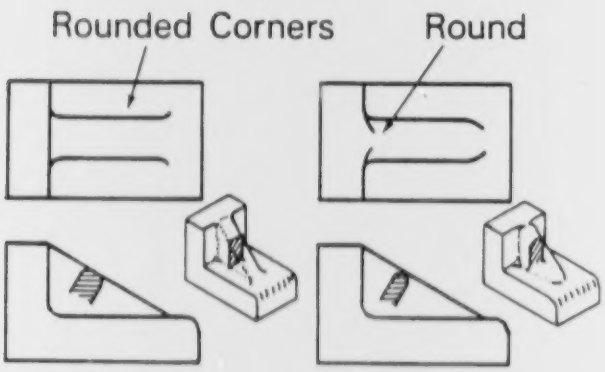


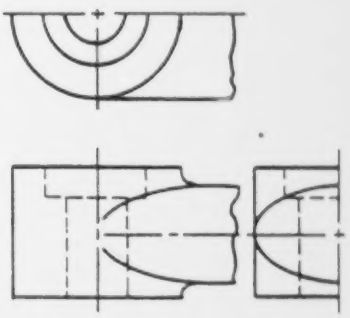


HO 1.14

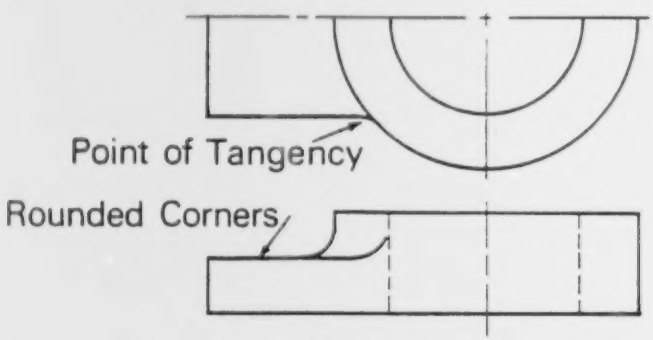
Fillets, Rounds, and Runouts HO 1.15







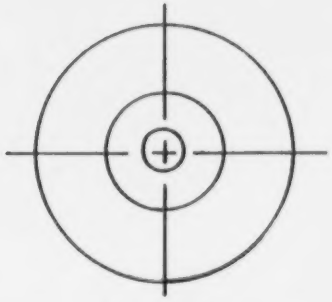
Runout Intersection Between a Cylinder and an Elliptical Part



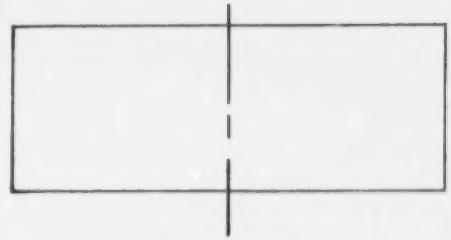
Runout Intersection Between a Cylinder and Rounded Part

Projection of Fillet and Round Edges

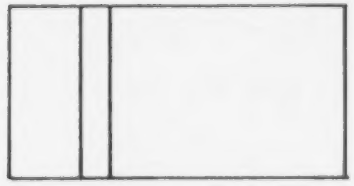
Incorrect



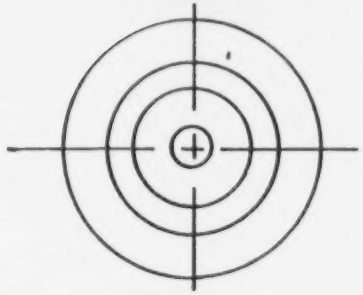
Incorrect



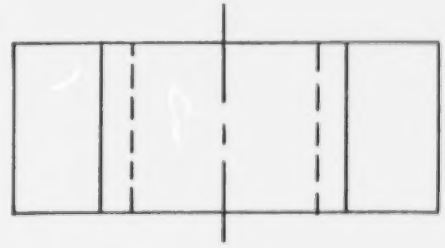
Incorrect



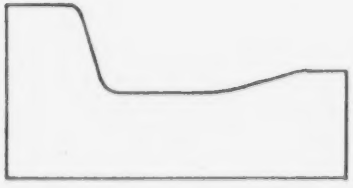
Correct

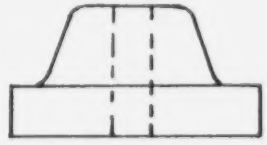


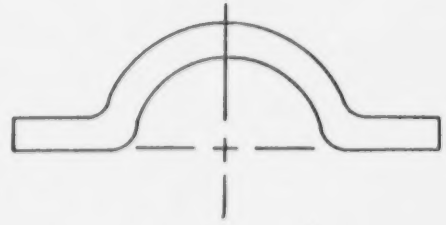
Correct



Correct

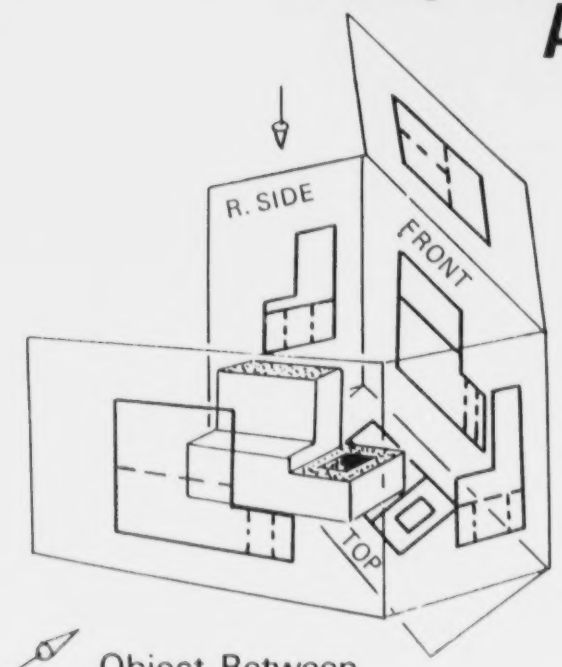




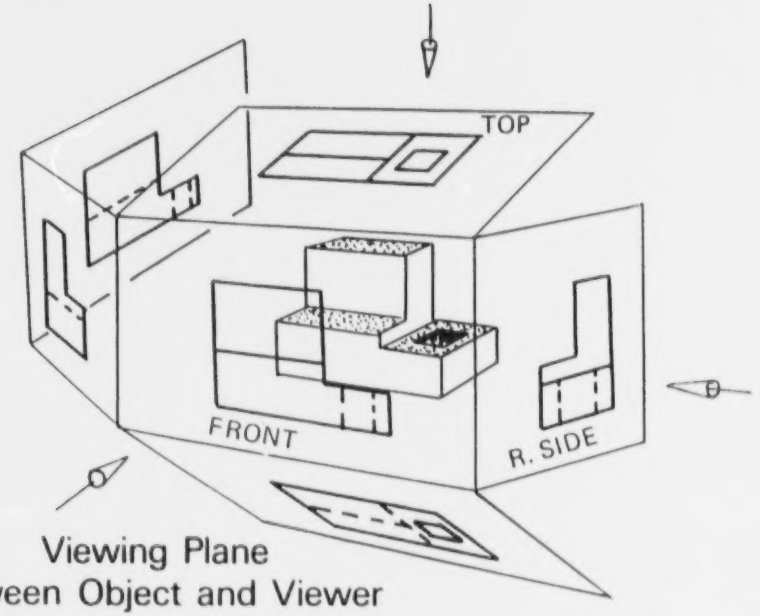


HO 1.16

Comparison Between First and Third Angle Projection

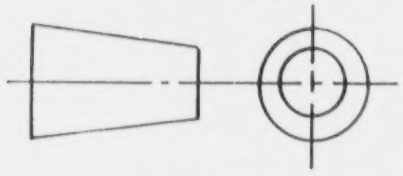


Object Between
Plane and Viewer



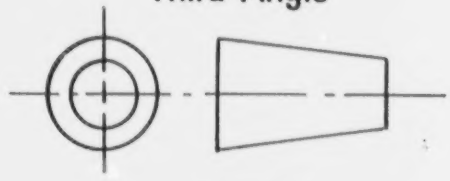
Viewing Plane
Between Object and Viewer

First Angle



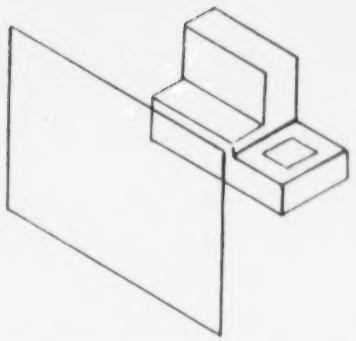
Symbol

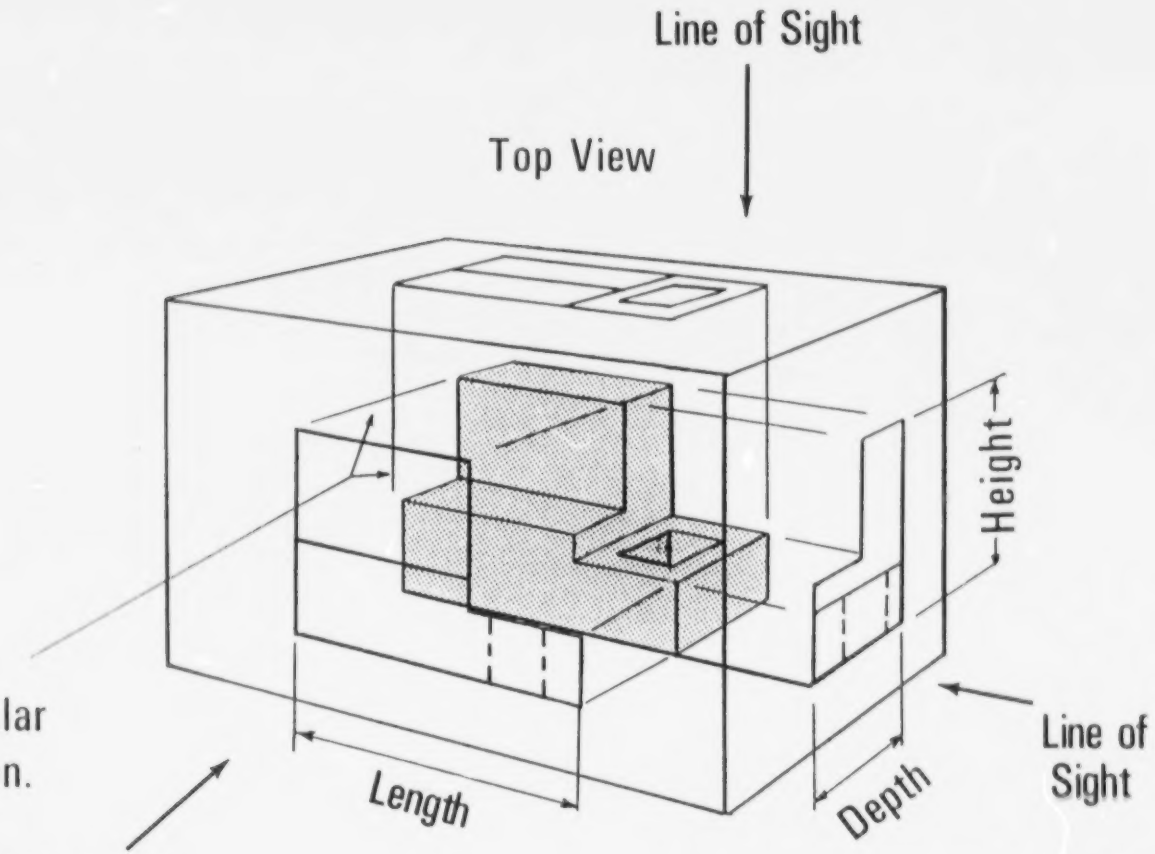
Third Angle



Symbol

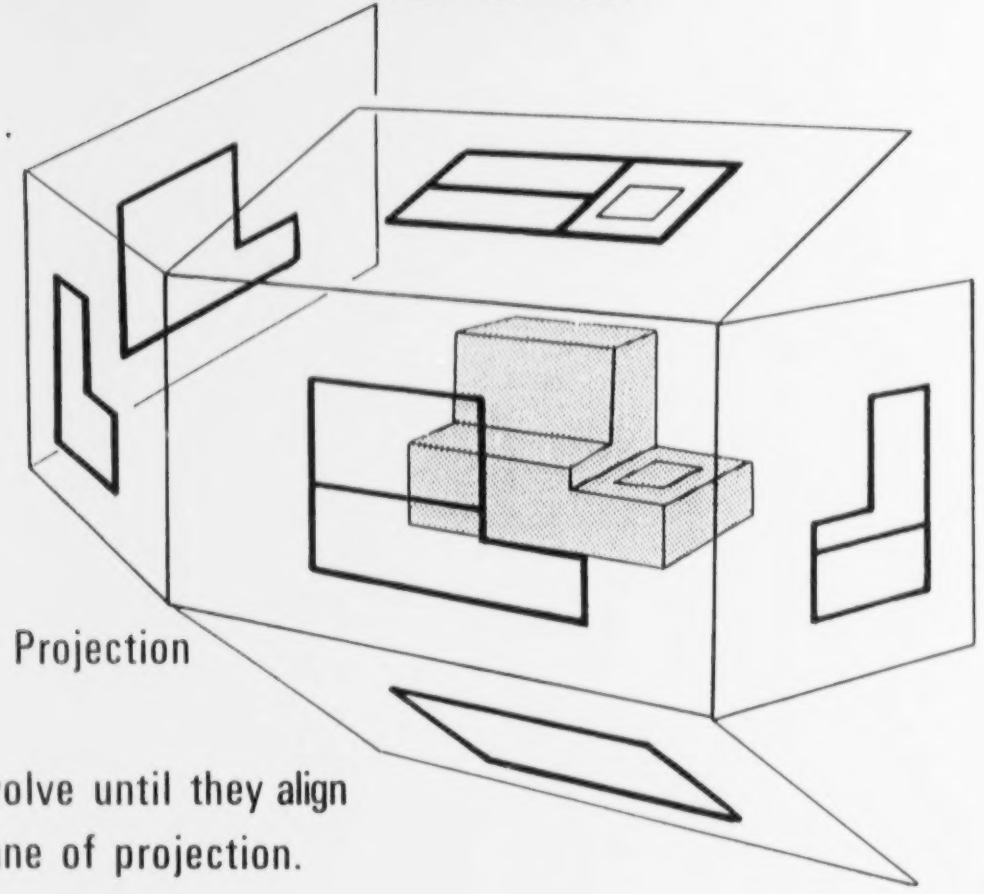
Orthographic Projection





TM 1.2

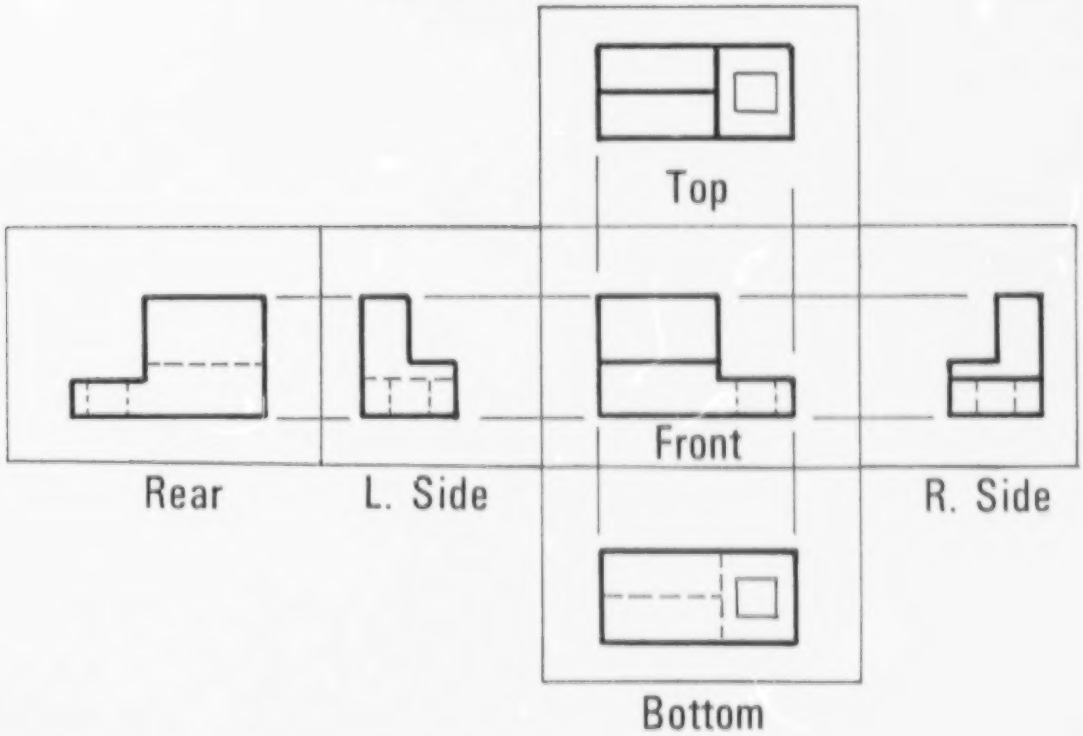
Orthographic Projection Continued



Front Plane of Projection

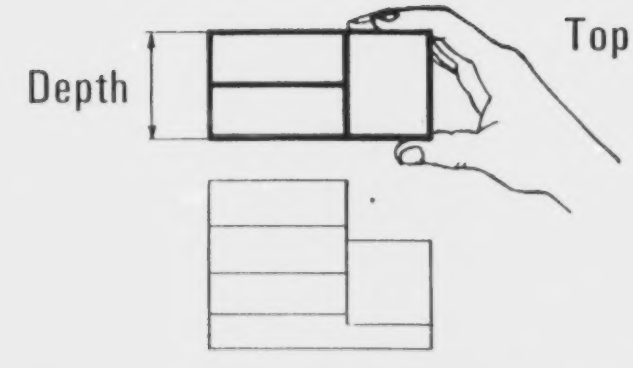
All planes revolve until they align with front plane of projection.

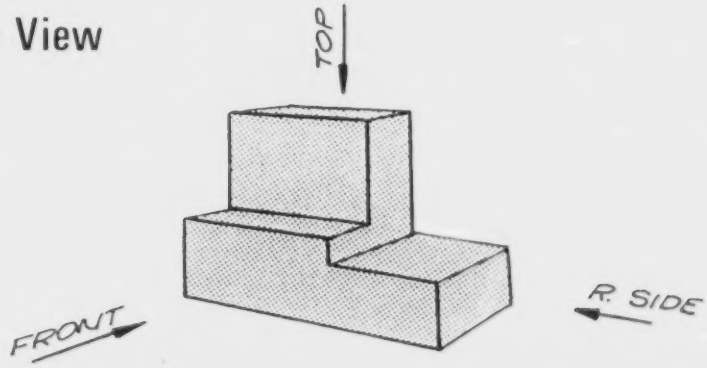
Orthographic Projection Continued



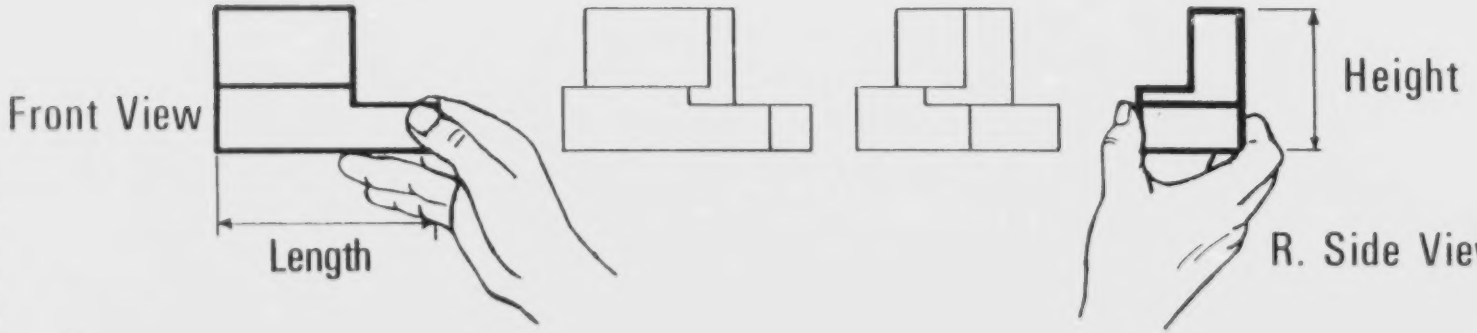
The six planes are layed on a flat plane as on a drawing surface.

Orthographic Projection Continued



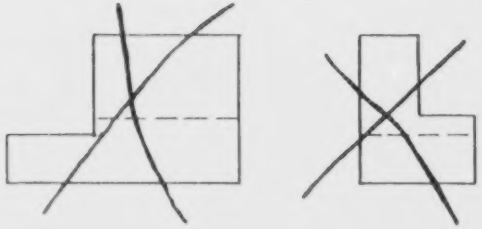


Draftsman should be able to rotate views in his mind as pictured below.



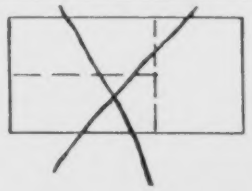
Principal Views in Orthographic Projection

Eliminate Views Not Needed

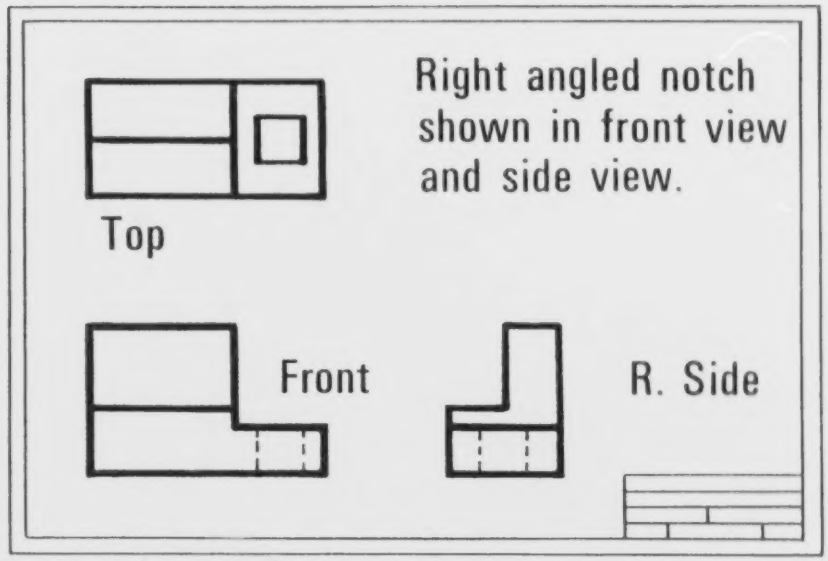


Rear

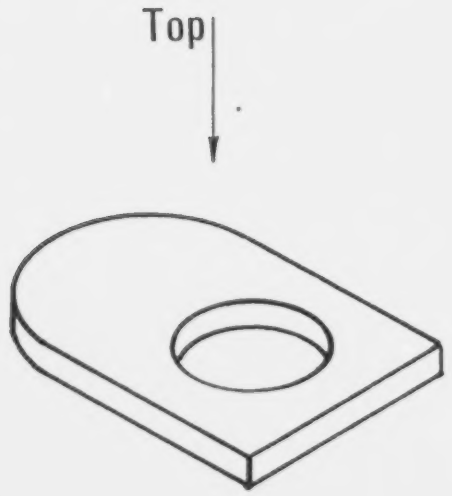
L. Side



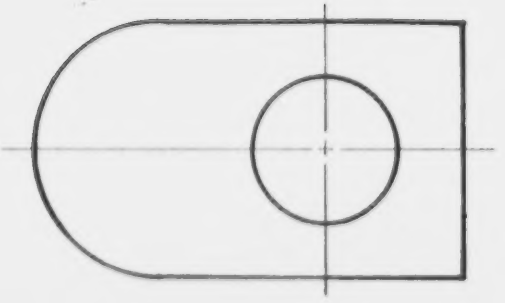
Bottom



One-View Drawings

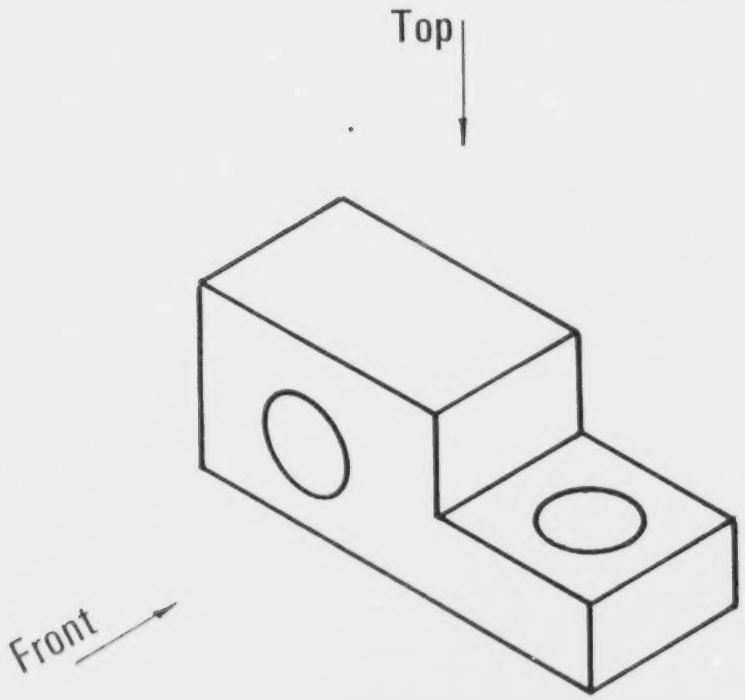


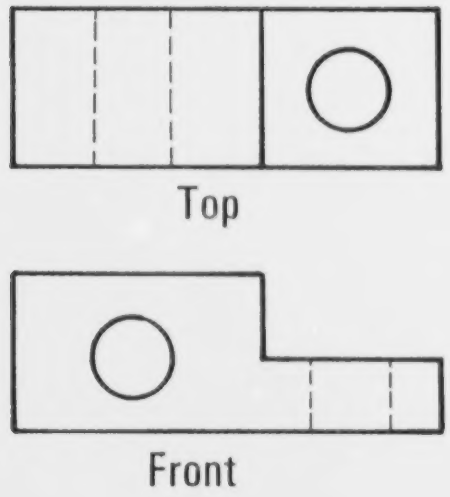
Objects with very little thickness require only one view.



Top View

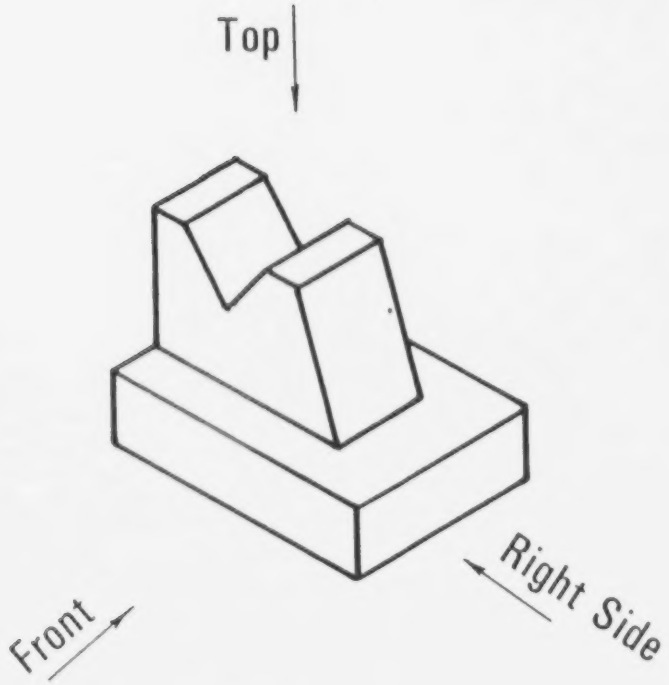
Two-View Drawings



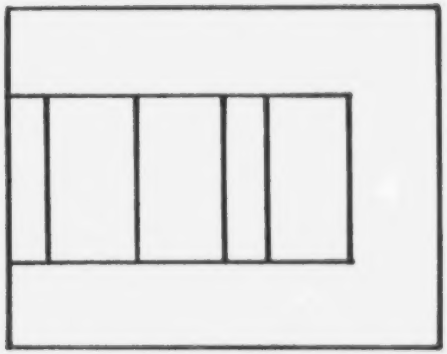


Some objects require only two views.

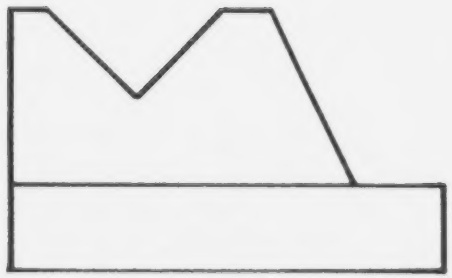
Three-View Drawings



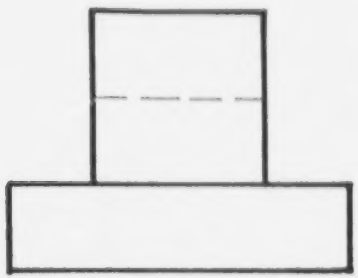
Some objects require three views to describe their shape.



Top View

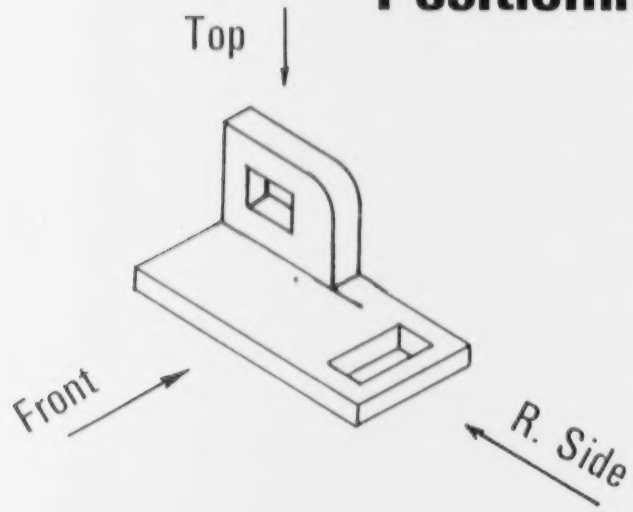


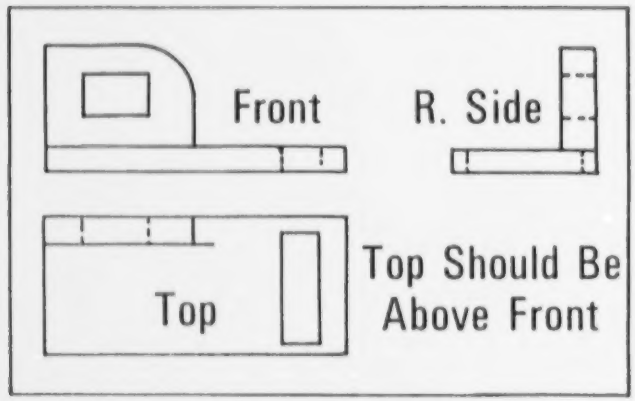
Front



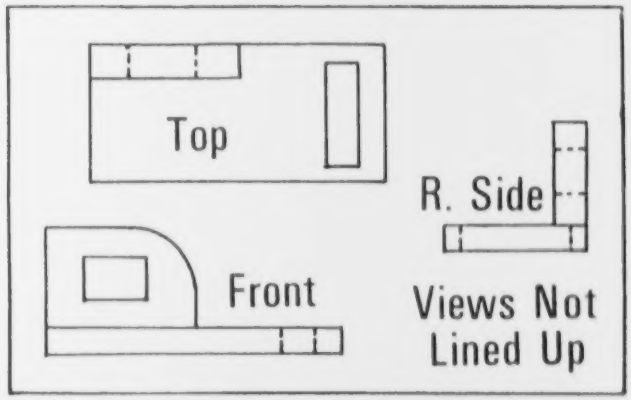
Right Side

Positioning of Views

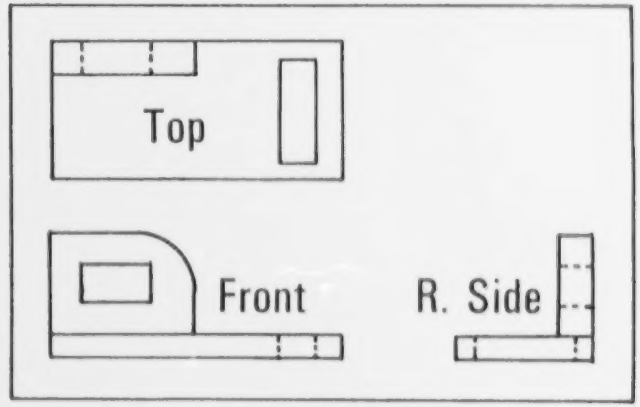




INCORRECT

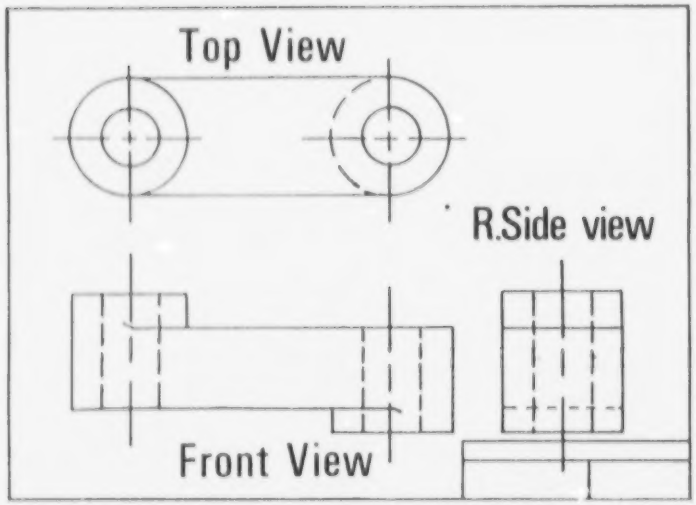


INCORRECT



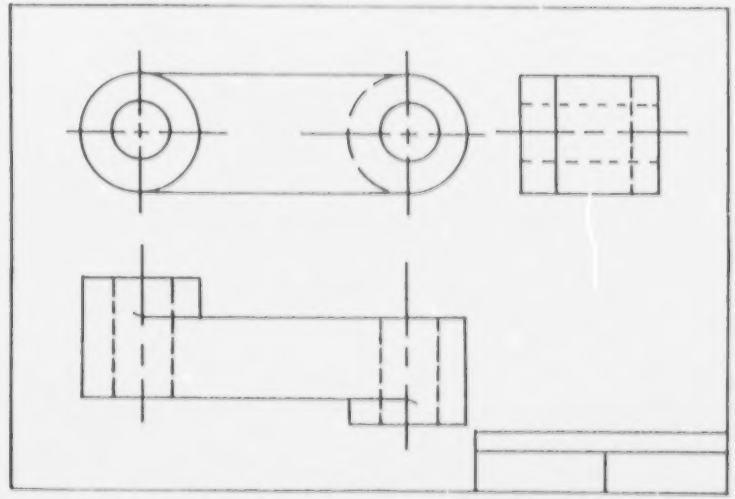
CORRECT

Position of Side View



NORMAL LOCATION

- Shape of object determines best location for side view.
- R. Side view can be projected off the front view or the top view.
- Space limitation requires alternate location.

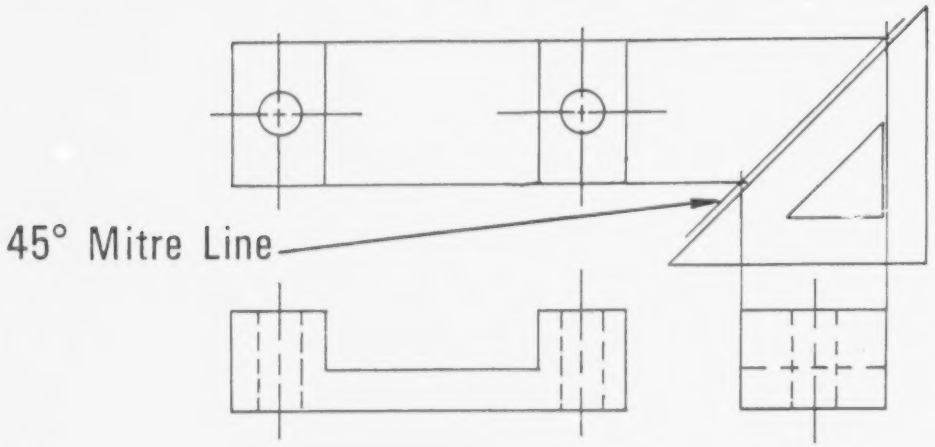


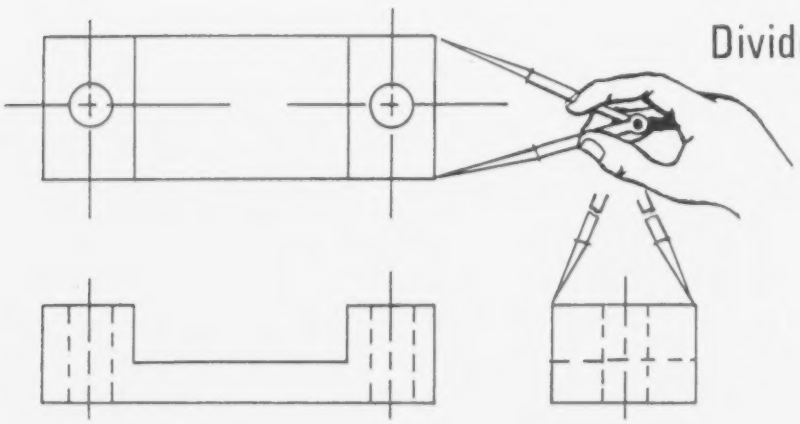
ALTERNATE LOCATION

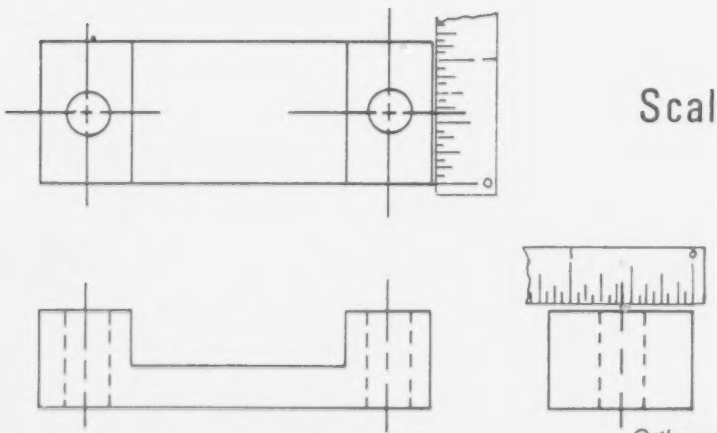
TM 1.11

TM 1.12

Methods of Transferring Dimensions

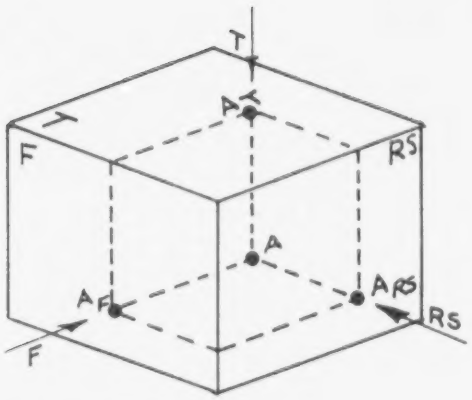




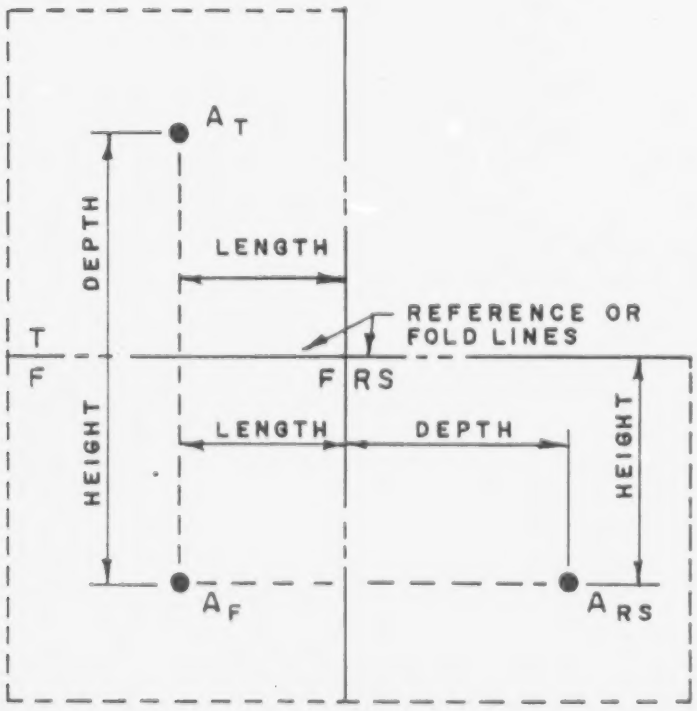


Visualization of a Point

TM 1.13

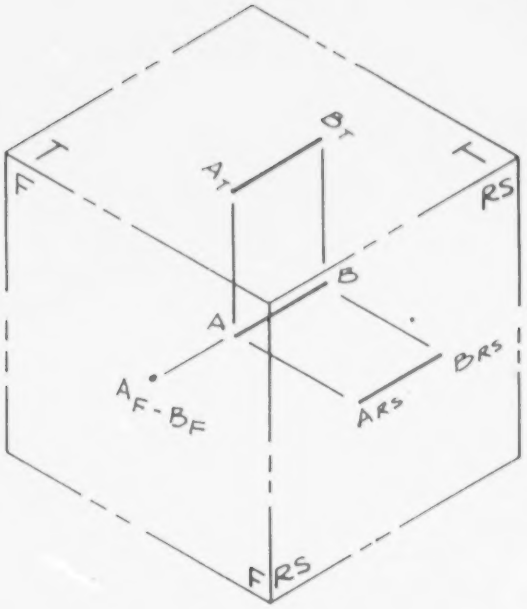


Space Picture

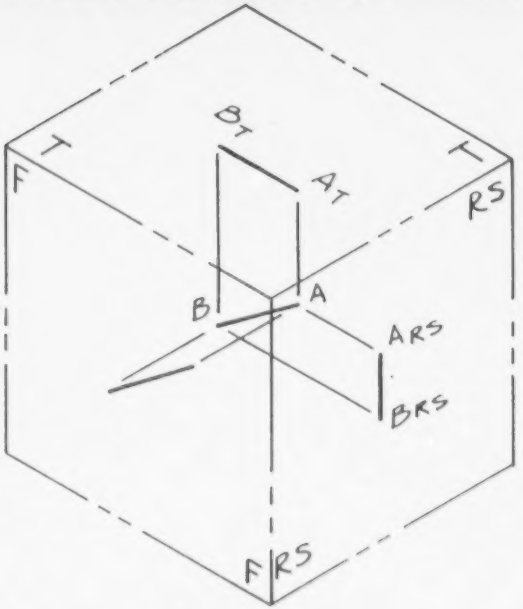


Orthographic View

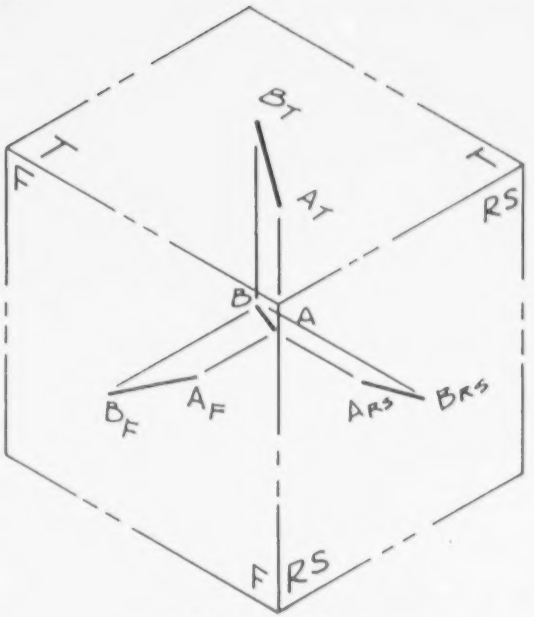
Visualization of Lines



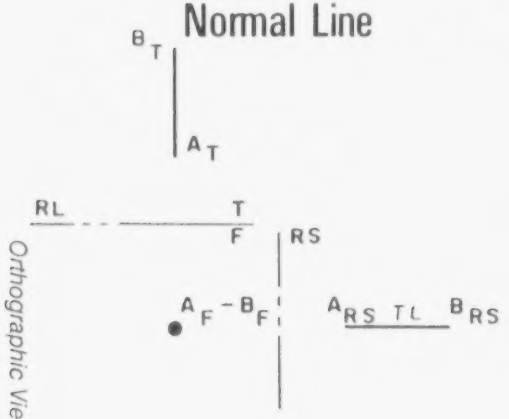
Normal Line

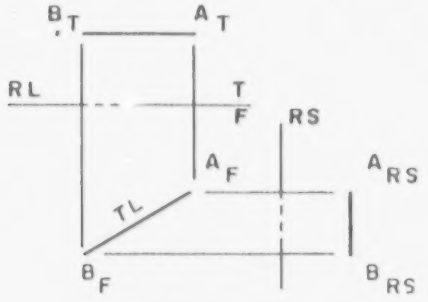


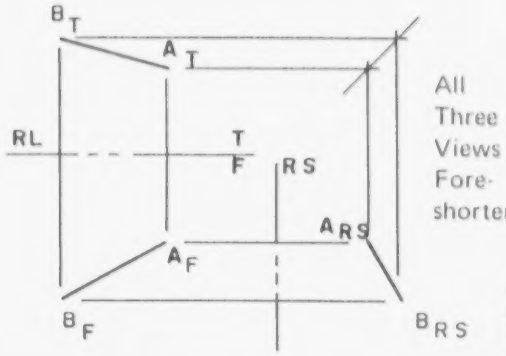
Inclined Line



Oblique Line





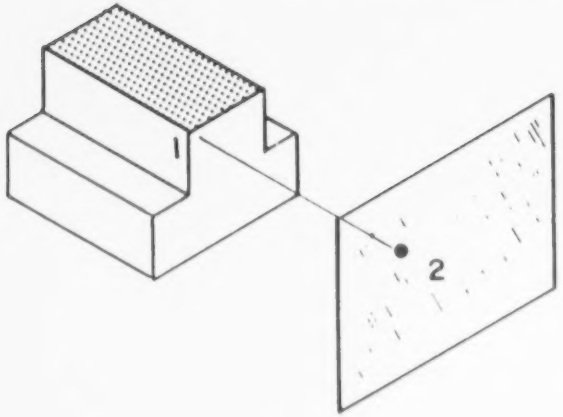


All Three Views Fore-shortened

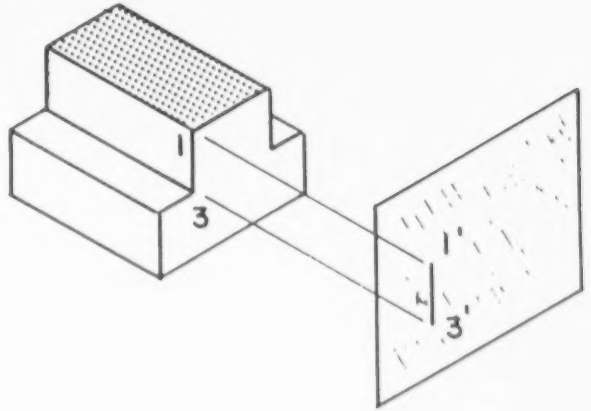
TM 1.14

Orthographic Views 77

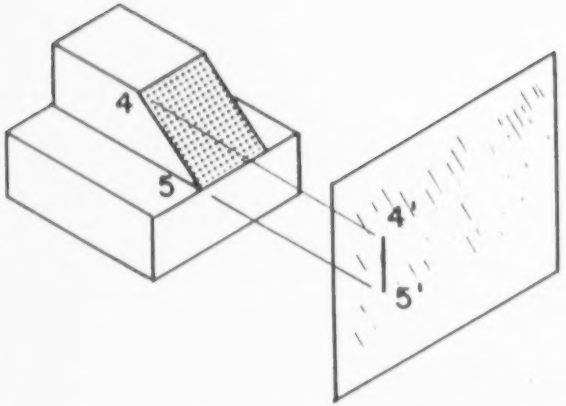
Projection of Lines in Orthographics



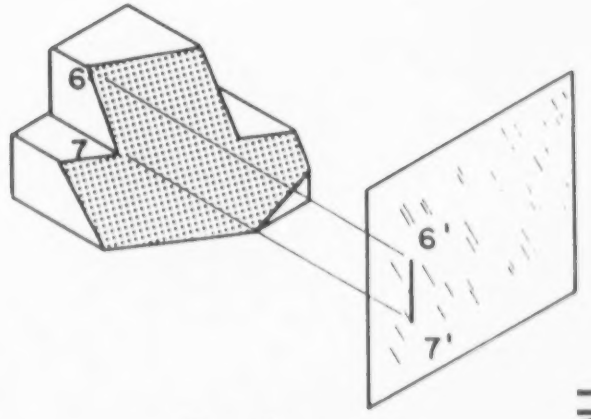
Point



True Length Line



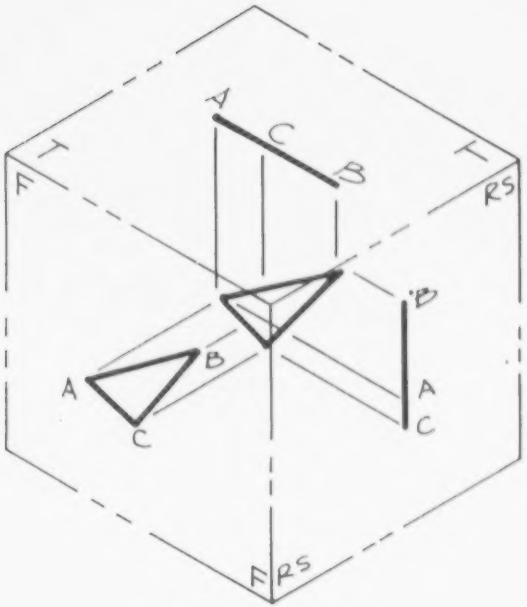
Foreshortened



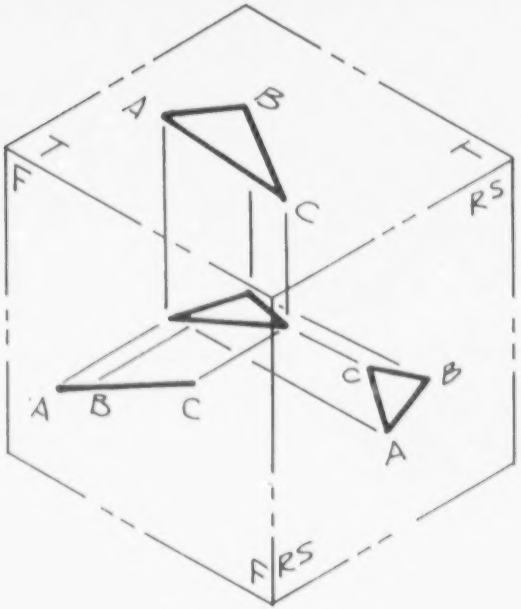
Foreshortened

TM 1.15

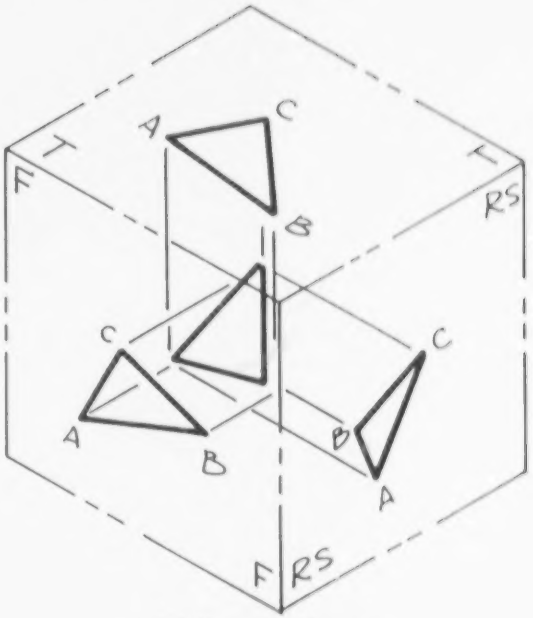
Visualization of Planes



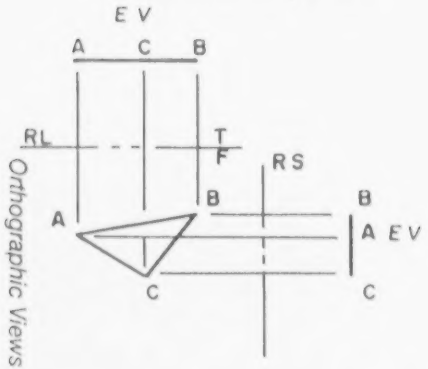
Normal plane

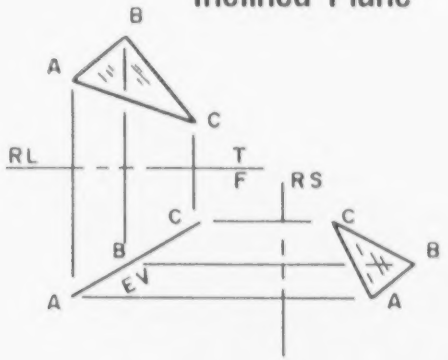


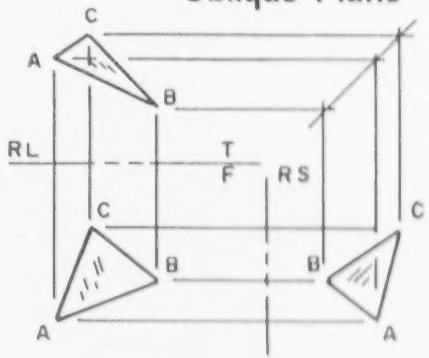
Inclined Plane



Oblique Plane





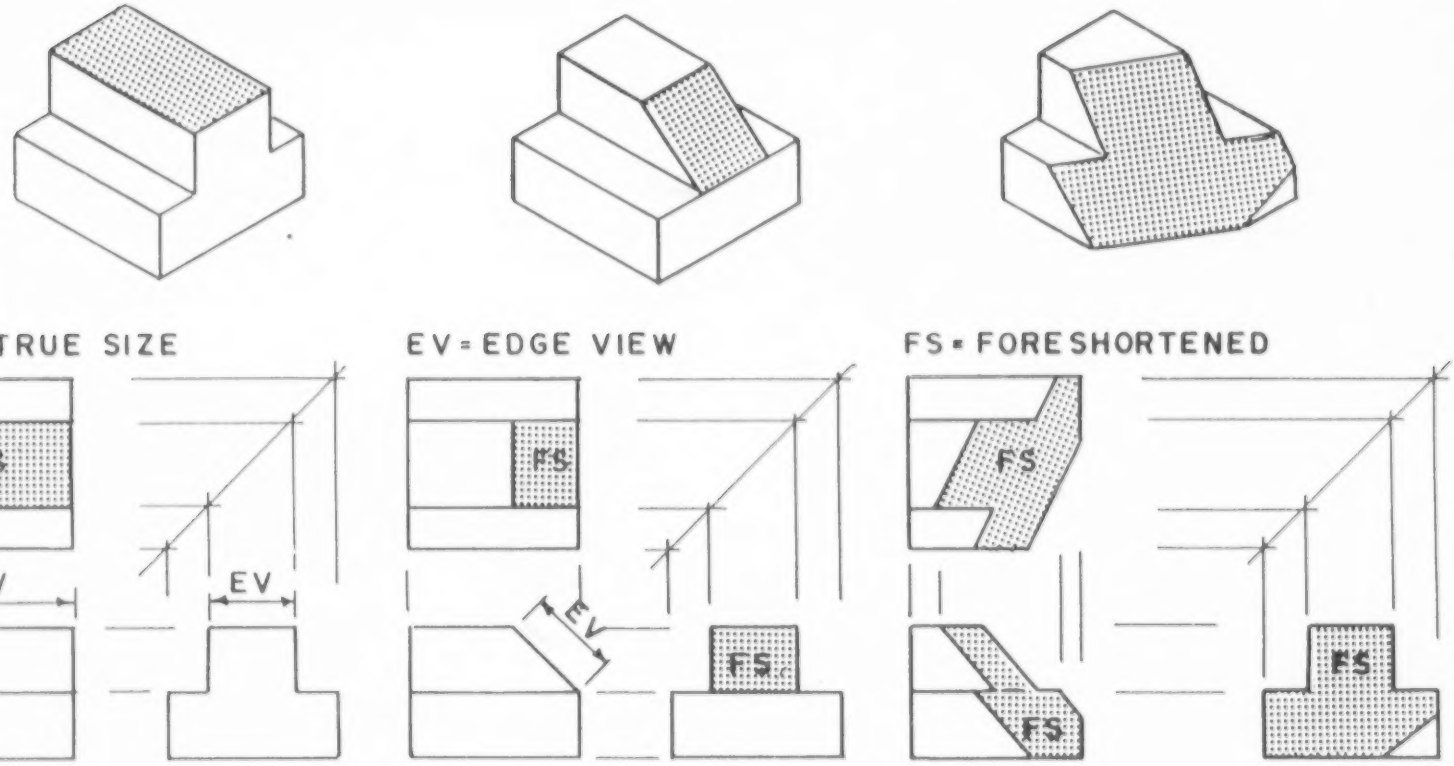


All Three Views Fore-shortened

TM 1.16

Orthographic Views 81

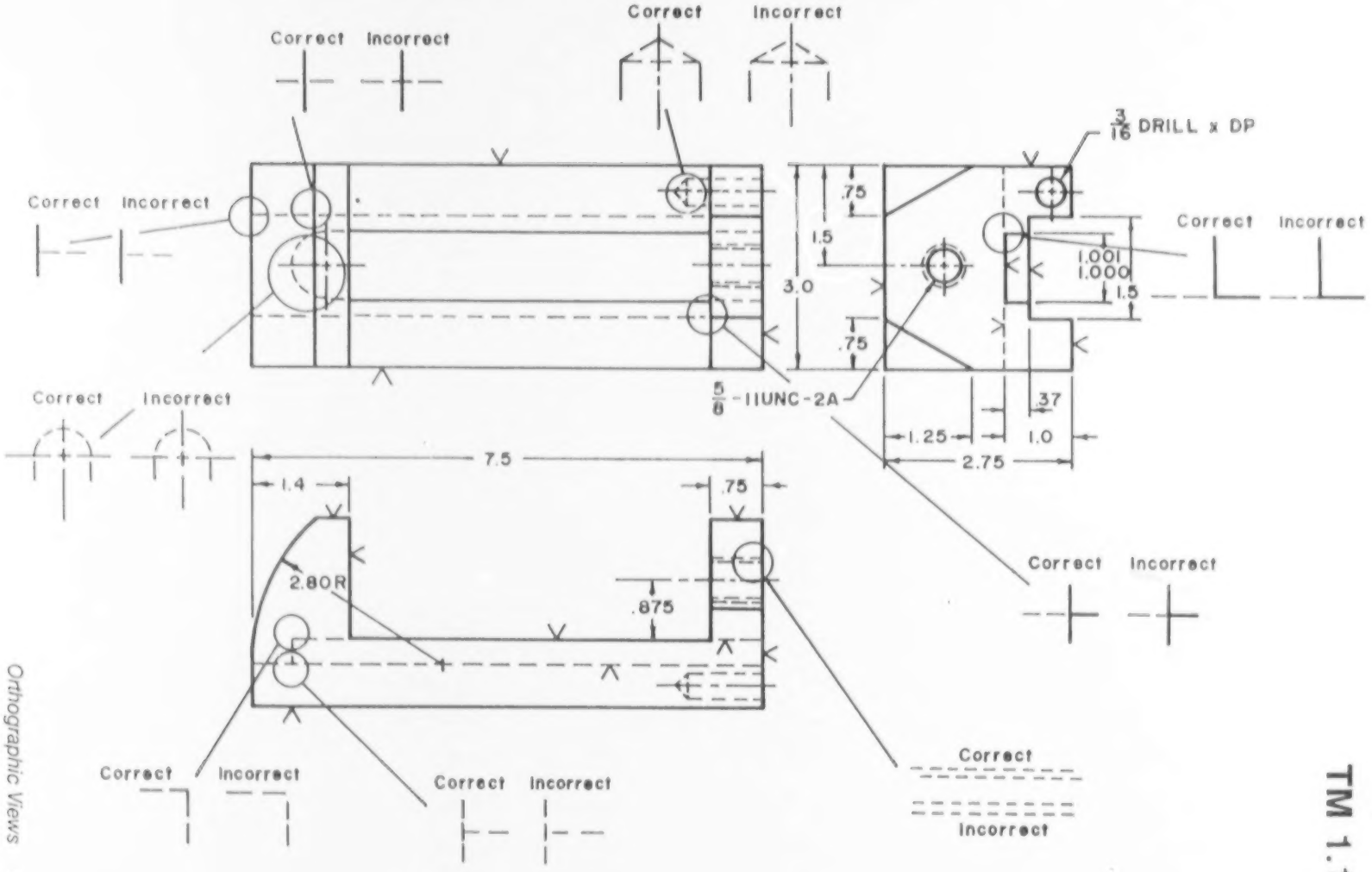
Planes in Orthographic Projection



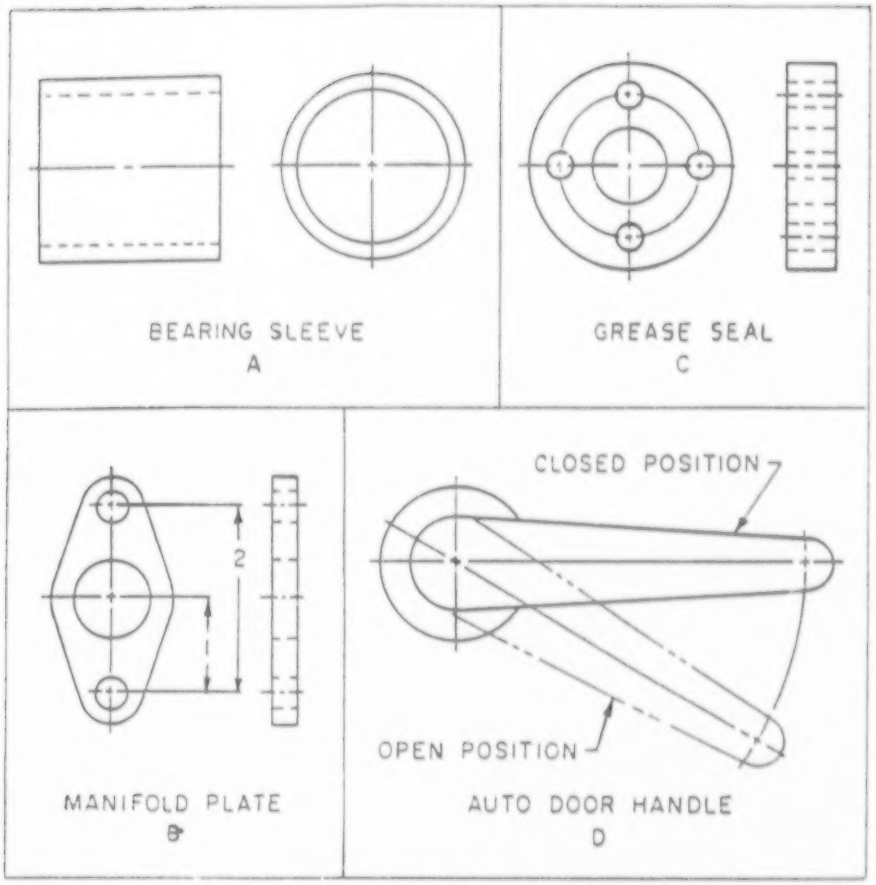
Normal Inclined Oblique

TM 1.17

Usage of Hidden Lines



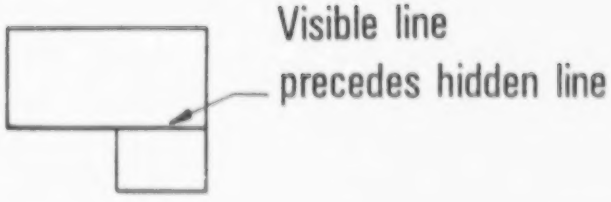
Usage of Center Lines

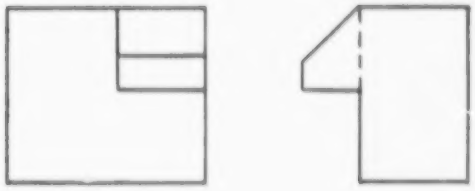


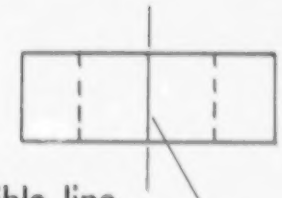
(From William Spence, Drafting Technology & Practice, p. 106)

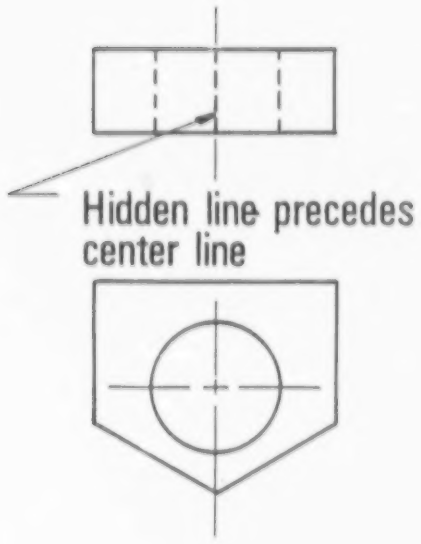
TM 1.20

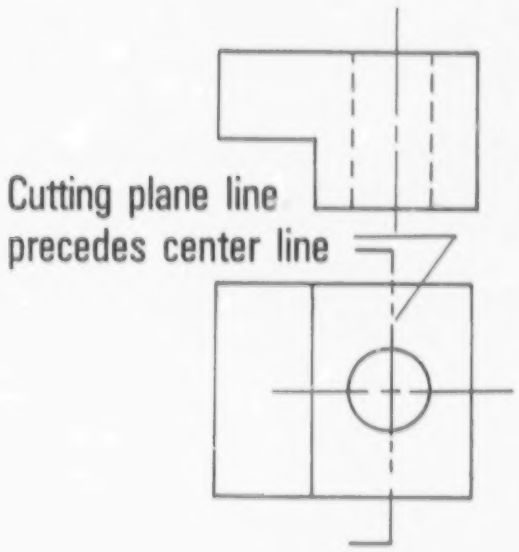
Line Precedence



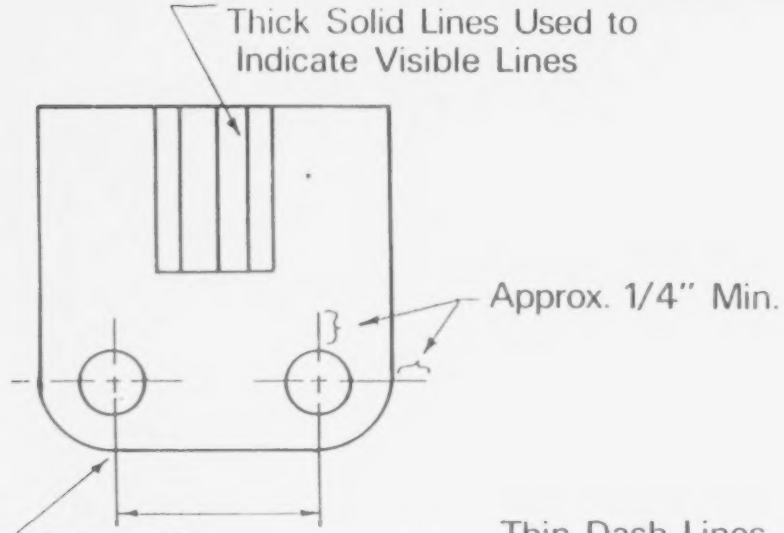


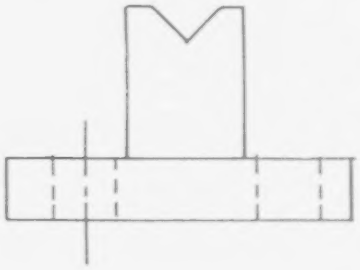


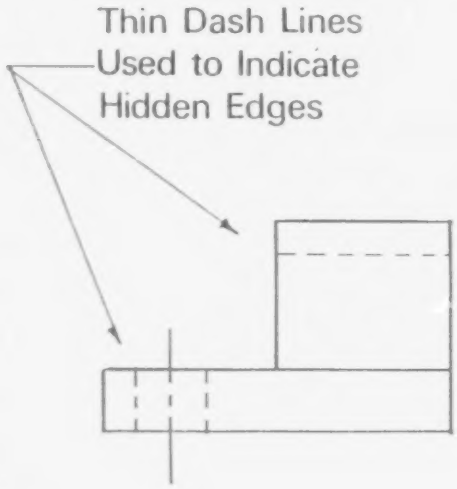


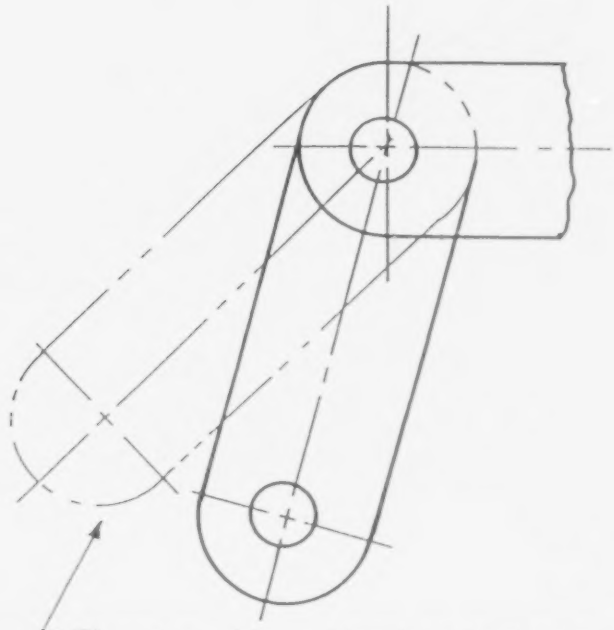


Line Thickness in Orthographic Drawing



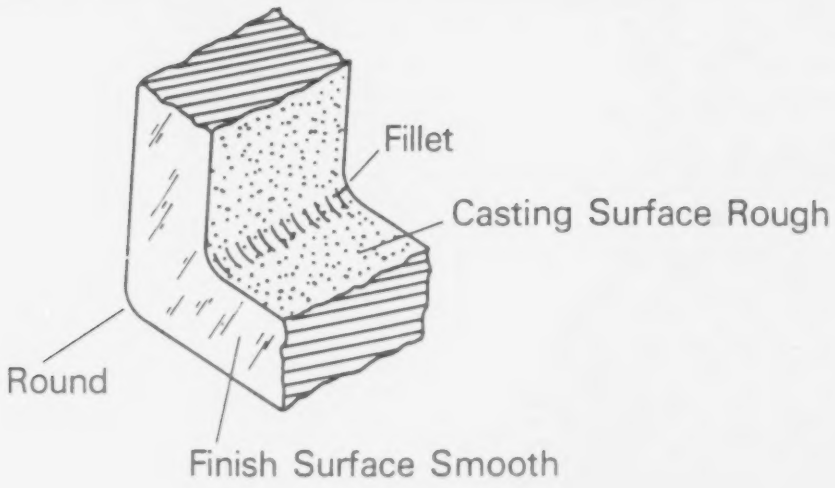


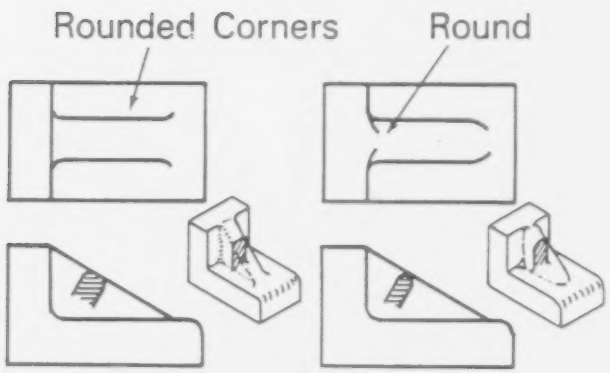


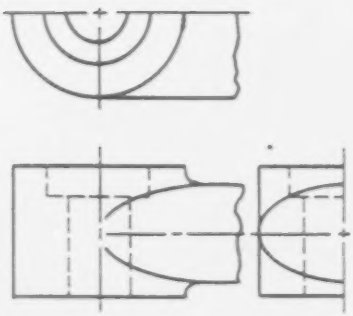


TM 1.21

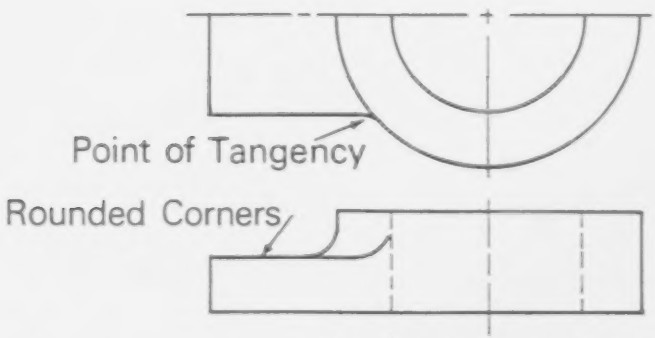
Fillets, Rounds, and Runouts TM 1.22





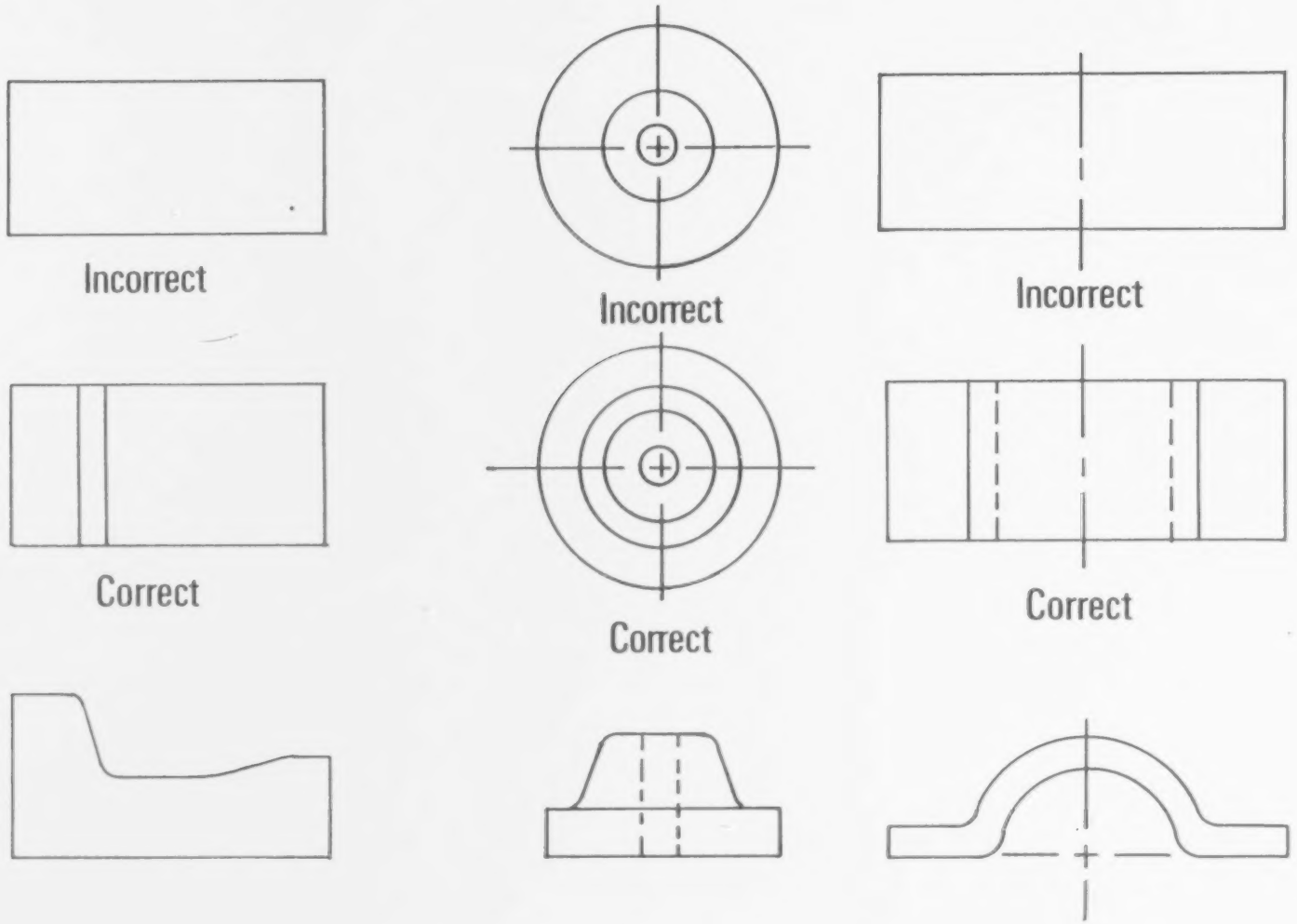


Runout Intersection Between a Cylinder and an Elliptical Part



Runout Intersection Between a Cylinder and Rounded Part

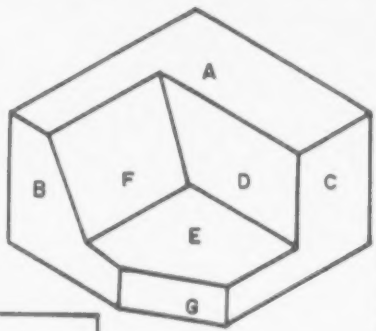
Projection of Fillet and Round Edges

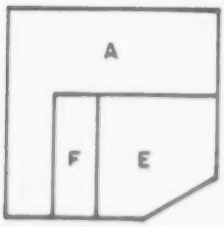


IDENTIFY TYPES OF PLANES IN ORTHOGRAPHIC VIEWS

Directions: Identify the types of planes in the drawings by writing normal, inclined, or oblique in the chart provided.

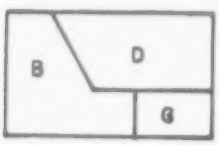
Problem A:

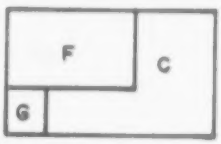


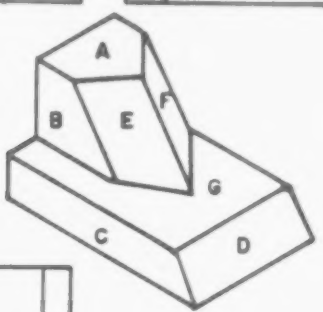


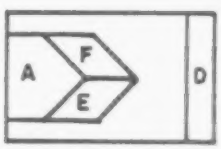
PLANE	TYPE
A	
B	
C	
D	
E	
F	
G	

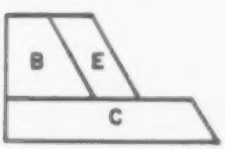
Problem B:









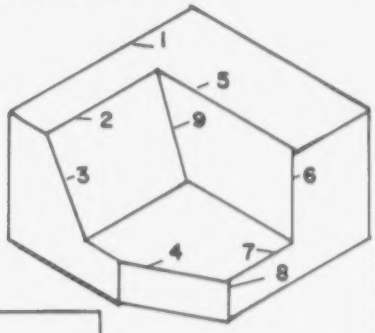


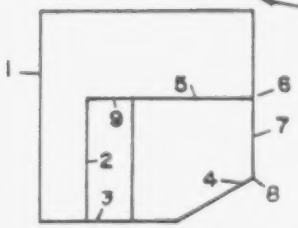
PLANE	TYPE
A	
B	
C	
D	
E	
F	
G	

IDENTIFY PROJECTION OF LINES IN ORTHOGRAPHIC VIEWS

Directions: Identify correct projection of lines in the drawings by writing point, true length, or foreshortened in the chart provided.

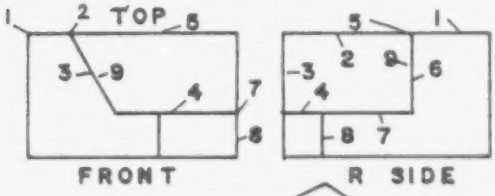
Problem A:

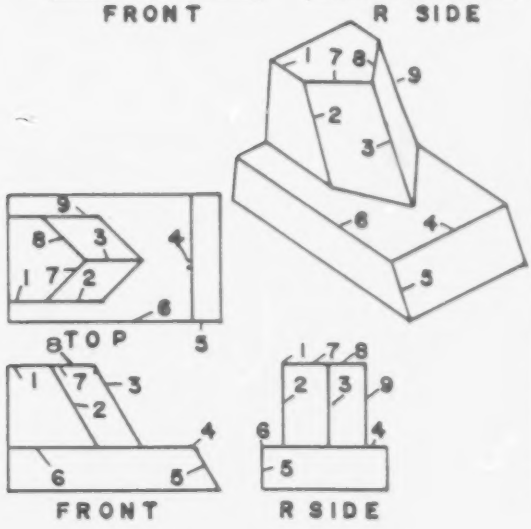




LINE	TOP	FRONT	R SIDE
1			
2			
3			
4			
5			
6			
7			
8			
9			

Problem B:



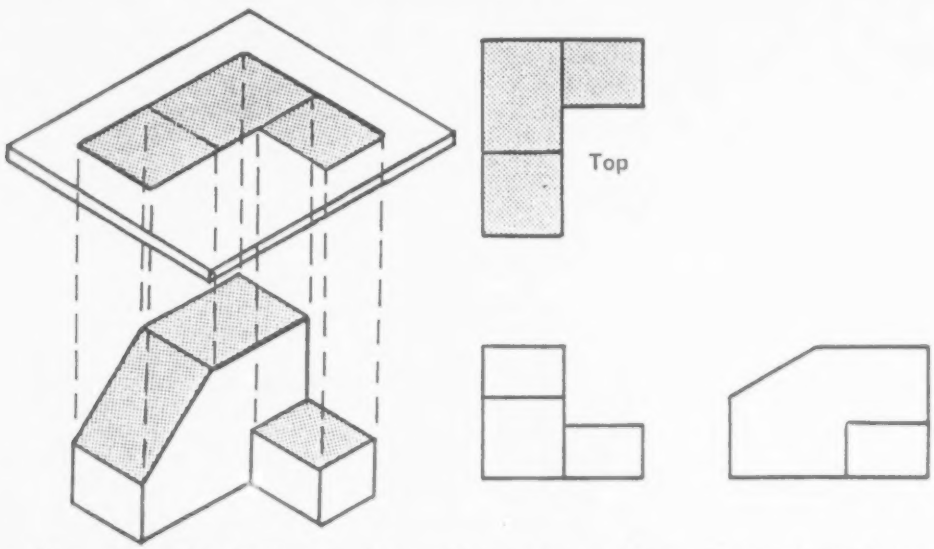


LINE	TOP	FRONT	R SIDE
1			
2			
3			
4			
5			
6			
7			
8			
9			

CONSTRUCT A TOP VIEW

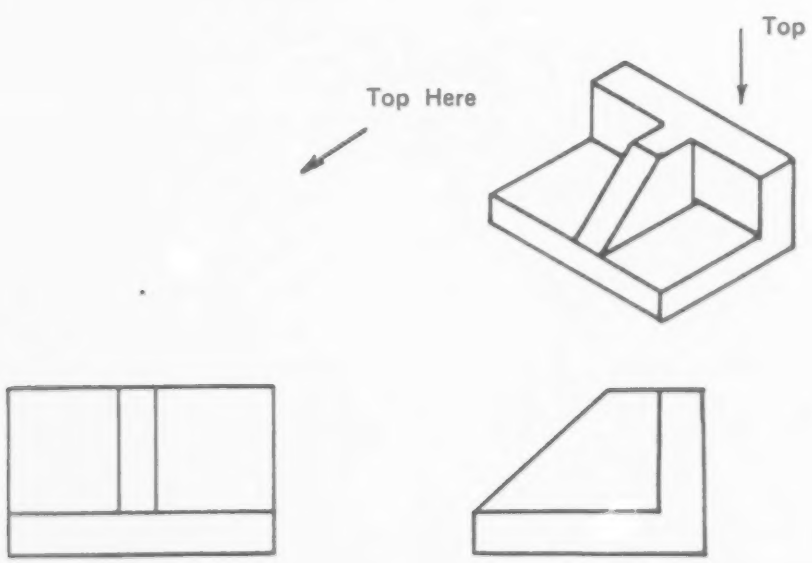
Premise: The top view is first viewed on an imaginary plane, and then drawn in its correct position using mitre method of transferring dimensions.

Example:

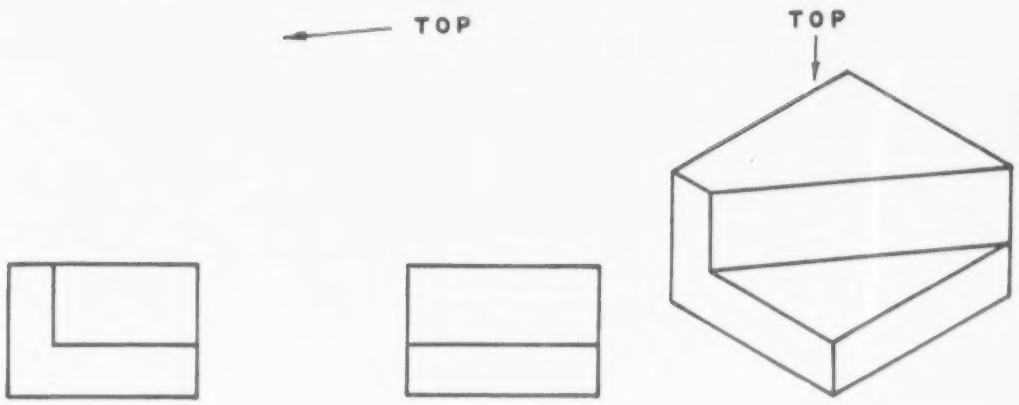


Directions: Align views with drafting machine and tape down. Construct top views of the following objects. Do not show hidden lines.

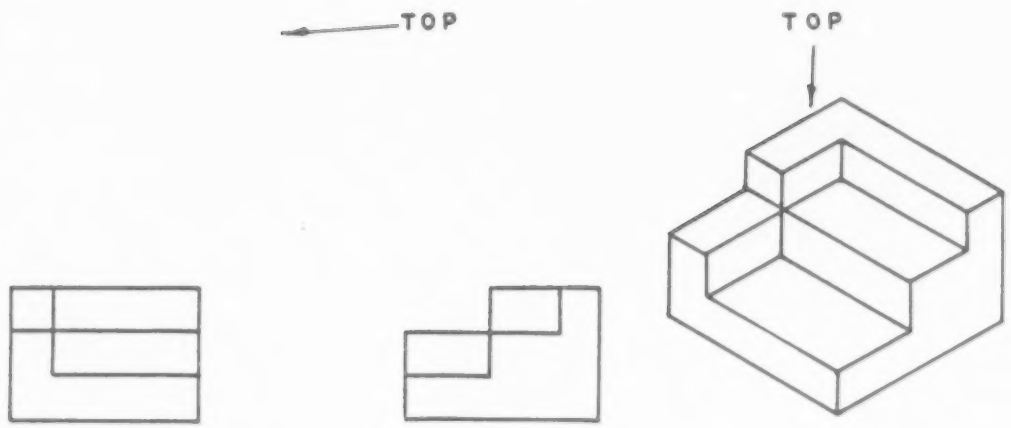
Problem A:



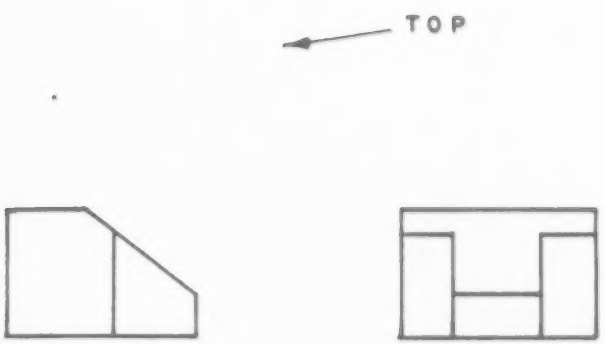
Problem B:



Problem C:



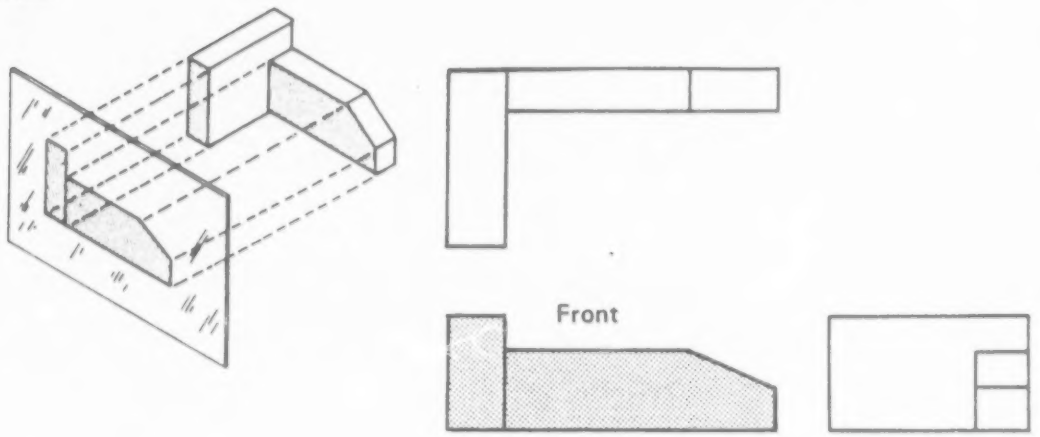
Problem D:



CONSTRUCT A FRONT VIEW

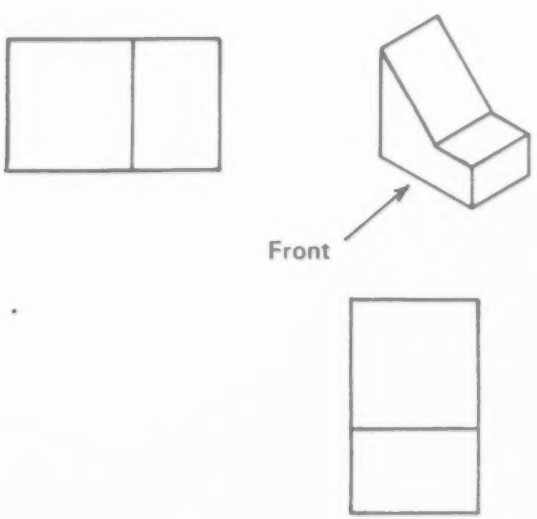
Premise: The front view is first viewed on an imaginary plane, and then drawn in its correct position.

Example:

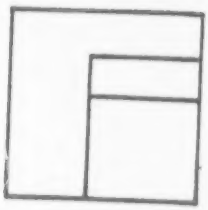


Directions: Construct the front views of the following objects. Align, tape down, **and do not show hidden lines.**

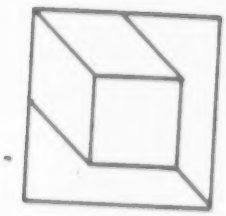
Problem A:



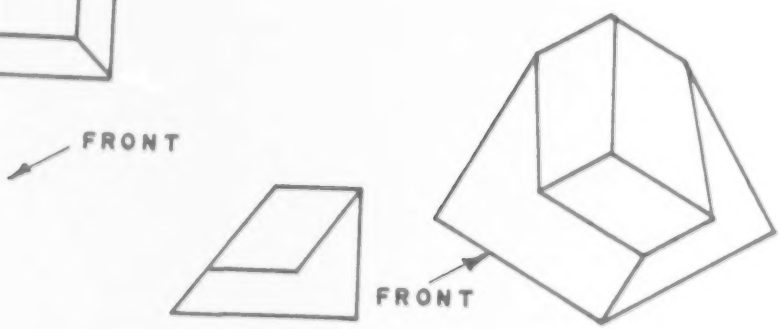
Problem B:

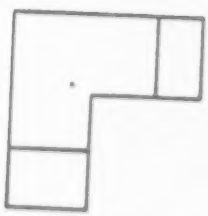


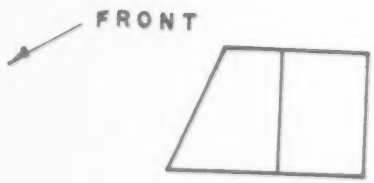
Problem C:



Problem D:



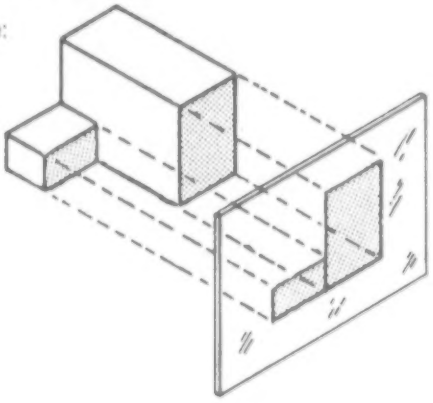


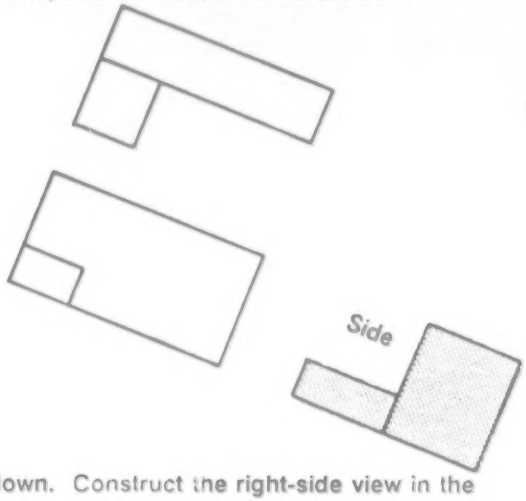


CONSTRUCT A RIGHT-SIDE VIEW

Premise: The end view is first viewed on an imaginary plane, and then drawn in its correct position (right or left).

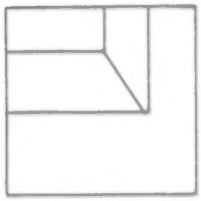
Example:

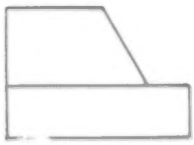




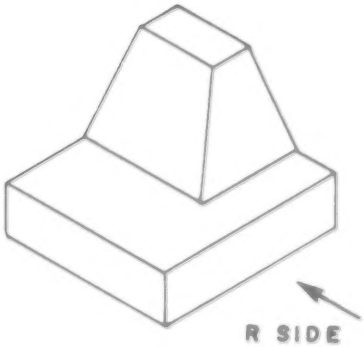
Directions: Align views with drafting machine and tape down. Construct the right-side view in the space provided.

Problem A:

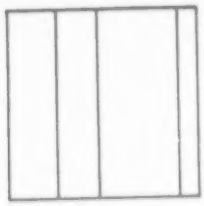




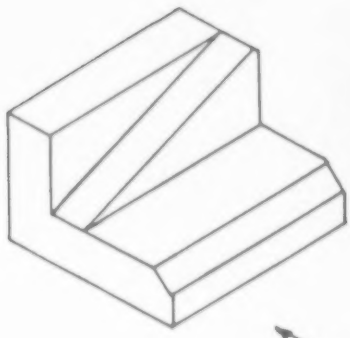
R SIDE



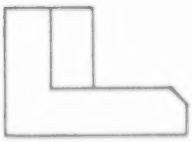
Problem B:



R SIDE

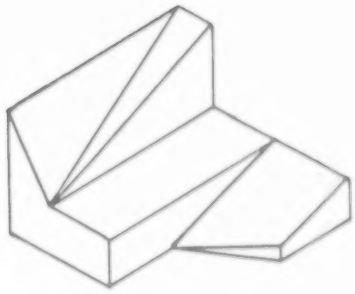


R SIDE



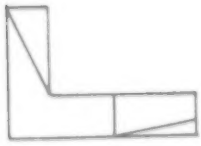
Problem C:

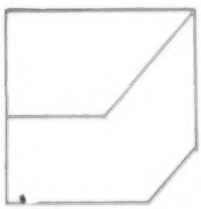
R SIDE



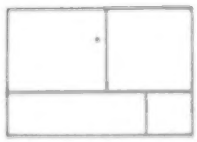
R SIDE

Problem D:





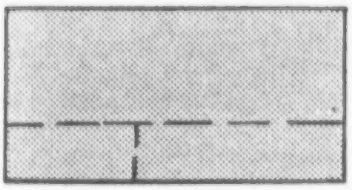
R SIDE

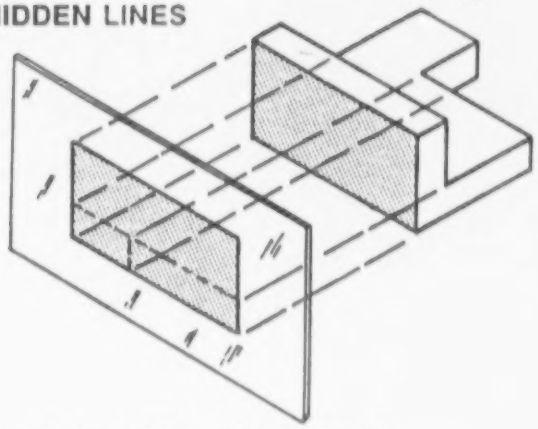


AS 1.6

CONSTRUCT MISSING HIDDEN LINES

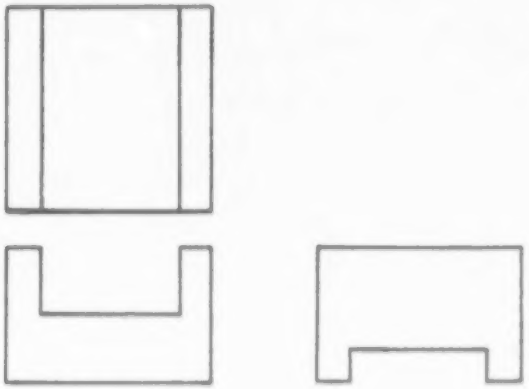
Example:



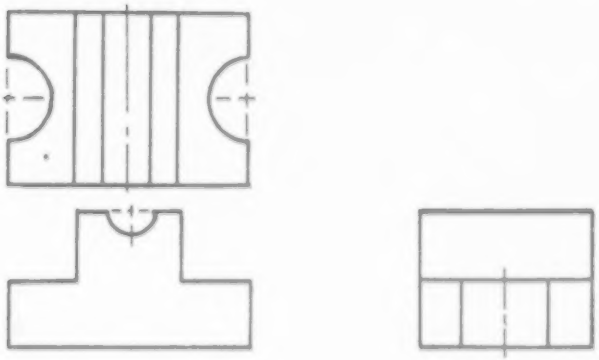


Directions: Construct the missing hidden lines in the views below. Align and tape down.

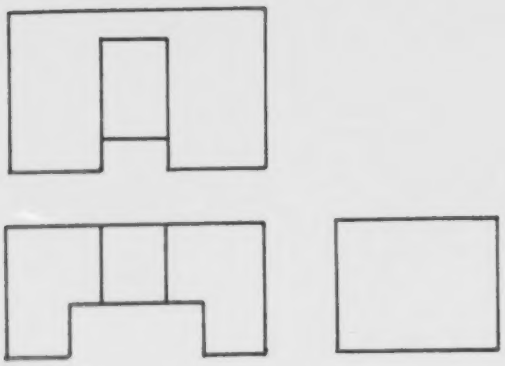
Problem A:



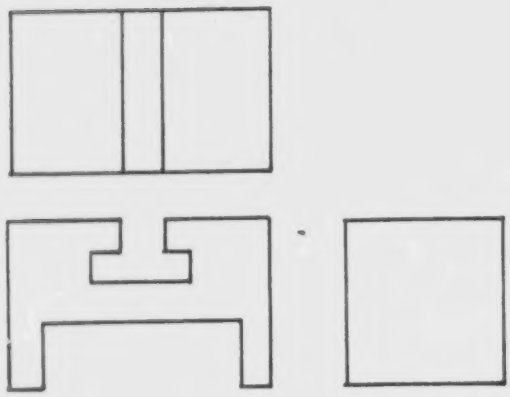
Problem B:



Problem C:



Problem D:



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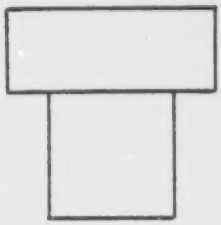
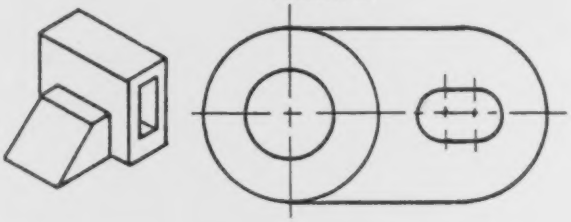
CONSTRUCT MISSING VISIBLE AND HIDDEN LINES

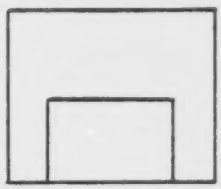
Directions: Study the views below and construct the missing visible and hidden lines. Align and tape down.

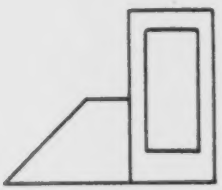
Problem A:

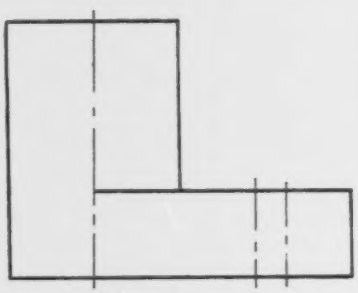


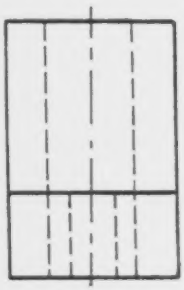
Problem B:



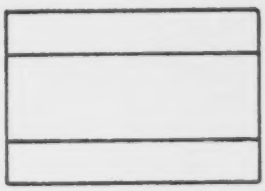




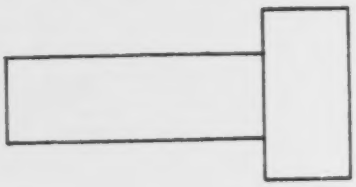


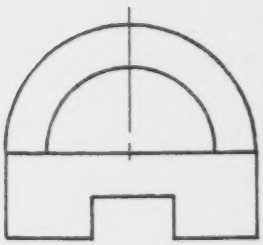


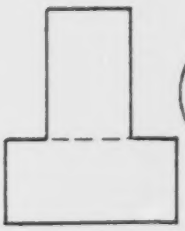
Problem C:

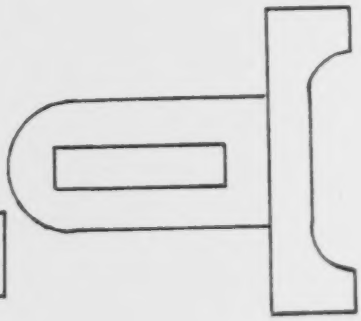


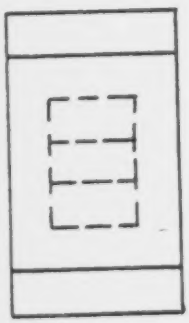
Problem D:



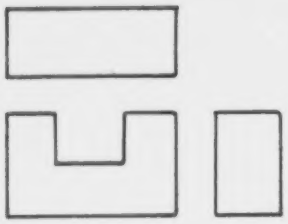




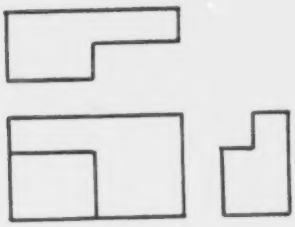




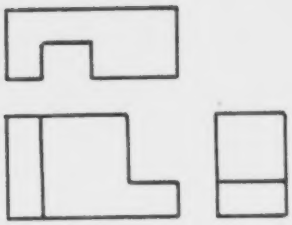
Problem E:



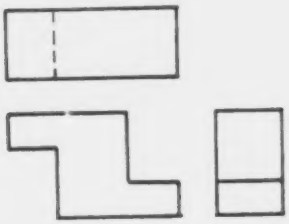
Problem F:



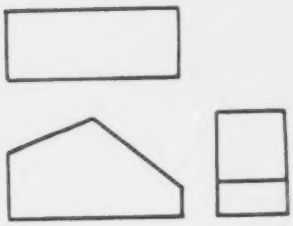
Problem G:



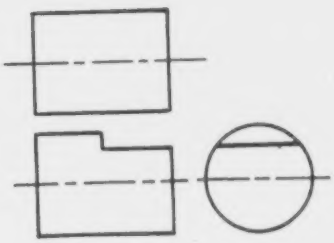
Problem H:



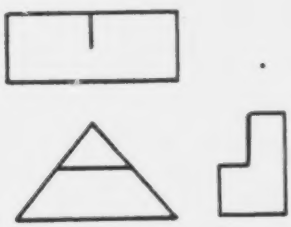
Problem I:



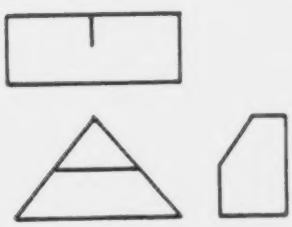
Problem J:



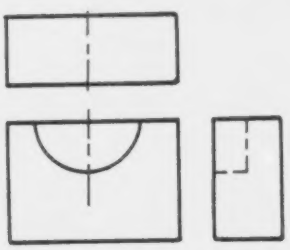
Problem K:



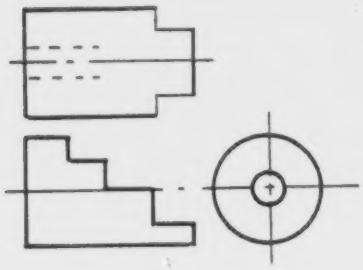
Problem L:



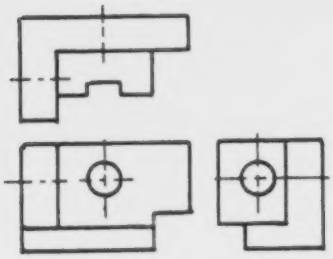
Problem M:



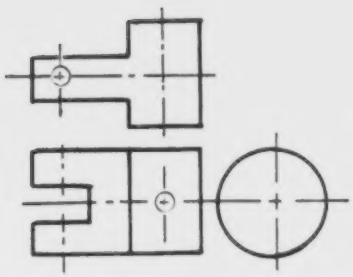
Problem N:



Problem O:



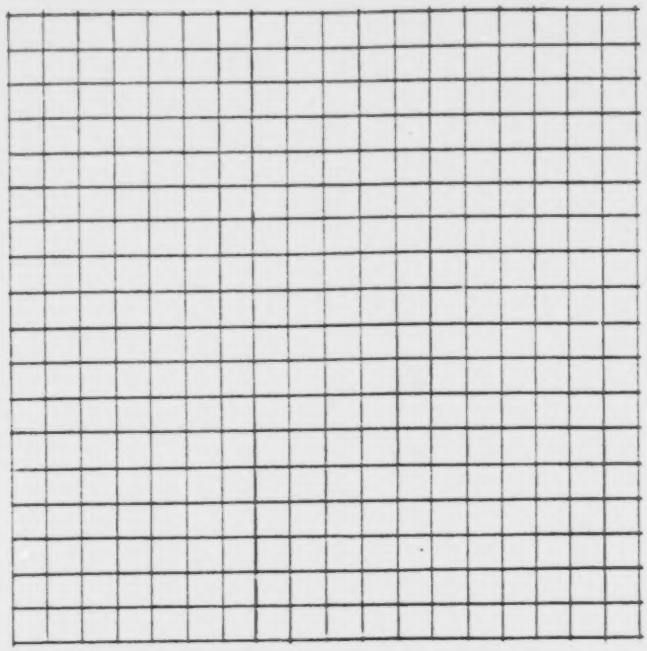
Problem P:

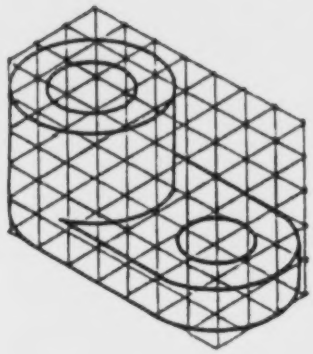


MAKE A TWO-VIEW SKETCH*

Directions: Sketch two views of the object using grids for measurements.

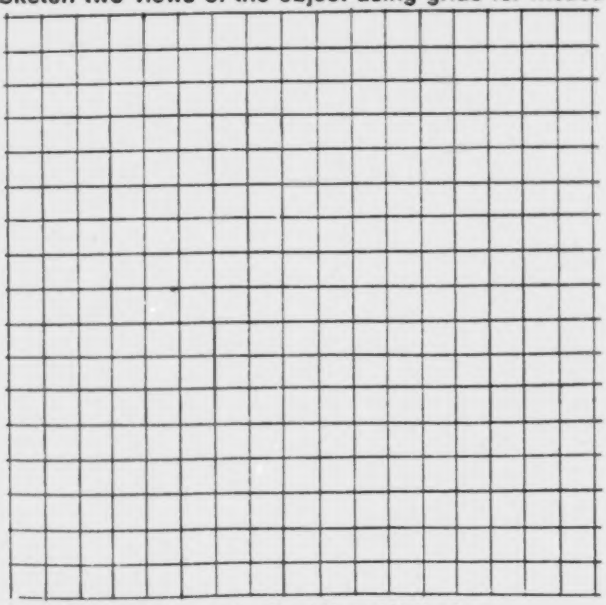
Problem A:

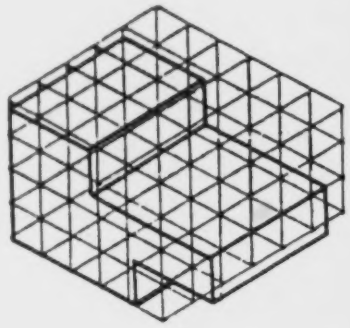




Directions: Sketch two views of the object using grids for measurements.

Problem B:



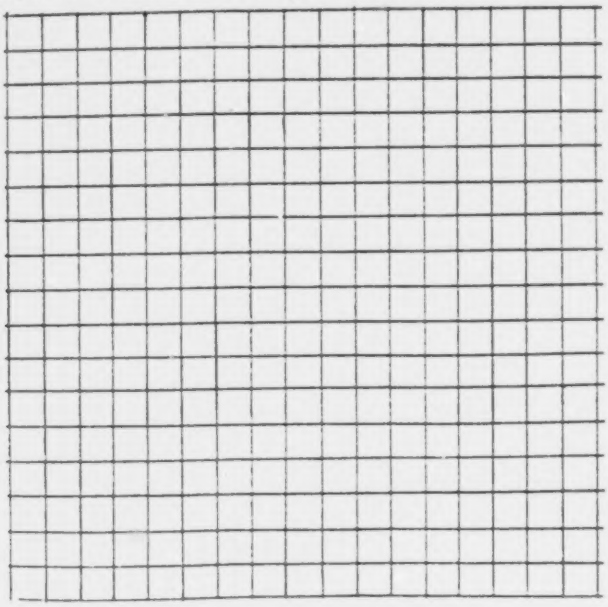


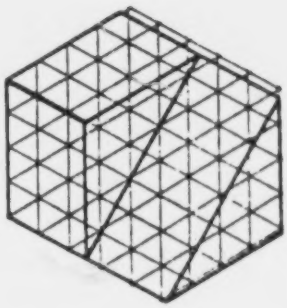
*Adapted from Drafting Problems, by Paul Ross Wallach.

MAKE A THREE-VIEW SKETCH*

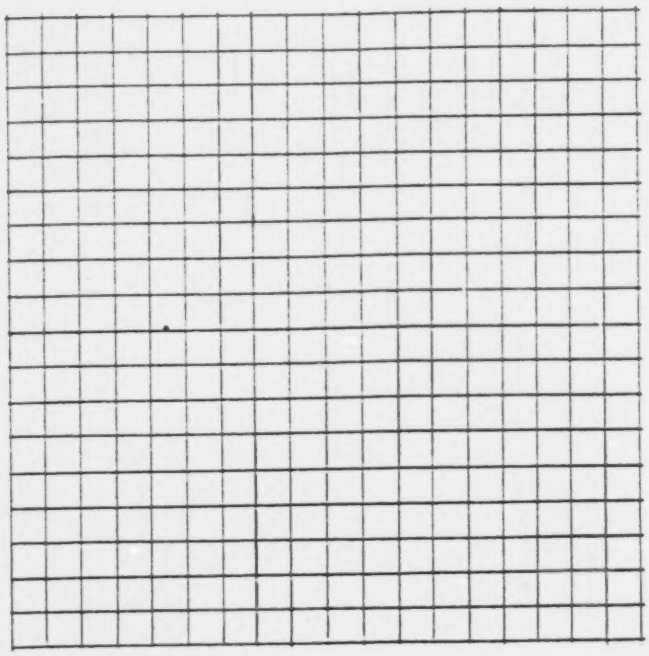
Directions: Sketch three-views of the object using grids for measurements.

Problem A:

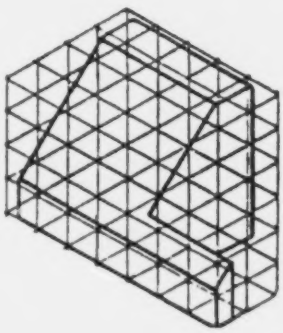




Problem B:



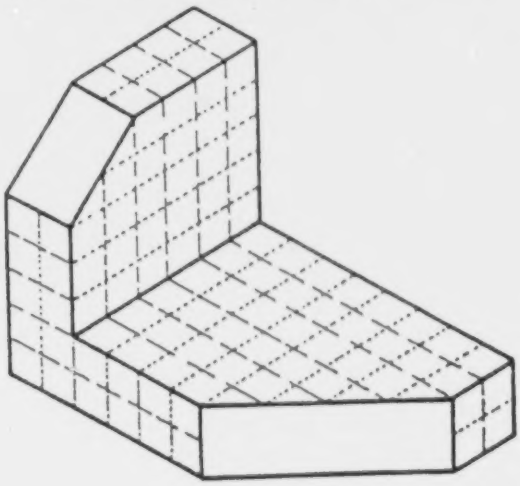
5 mm GRIDS



Problem C:

Directions: Sketch three views of the object using grids for measurements.

Problem:

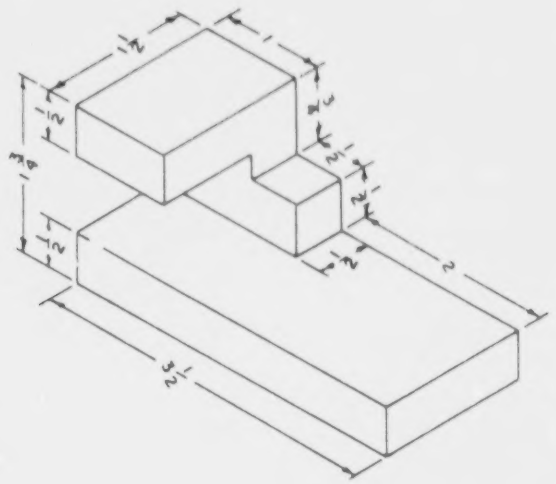


*Adapted from Drafting Problems, by Paul Ross Wallach.

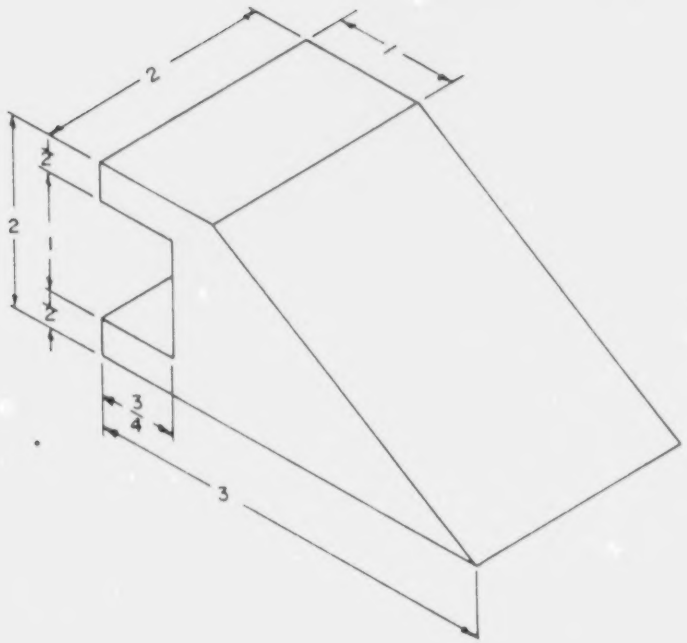
CONSTRUCT AN ORTHOGRAPHIC DRAWING

Directions: Construct three views of objects shown full size on B size vellum. Do not dimension.

Problem A: Normal surfaces



Problem B: Oblique surfaces



CONSTRUCT A RUNOUT

Premise: The arc of the runout is the same radius as the fillet or round. It may be drawn freehand, with an irregular curve, or with a circle template. The circle template procedure is used in the following example.

Example:

1. Project point of tangency from top to front view (Figure 1)

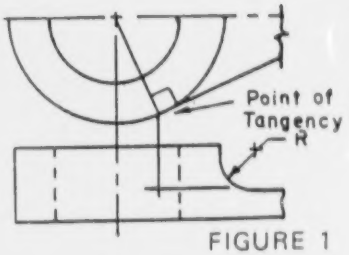


FIGURE 1

2. Construct 45° line through fillet's center to locate point A, and then project to point A1 (Figure 2)

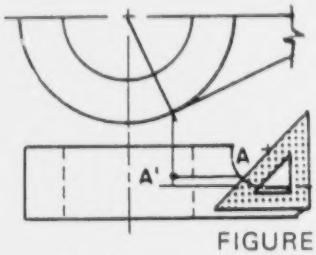


FIGURE 2

3. Center B is found by projecting from A1 to 45° to the horizontal projection through B1 (Figure 3)

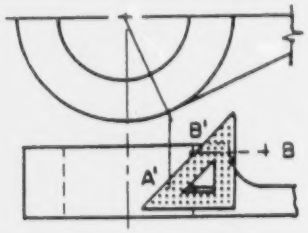


FIGURE 3

4. Use circle template to construct runout arc from A1 using center B (Figure 4)

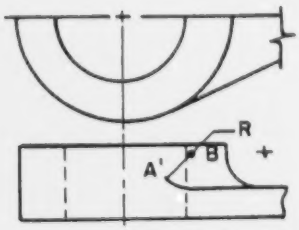
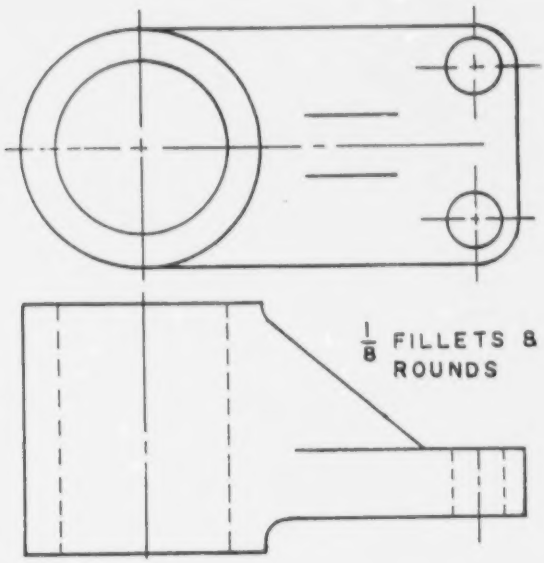


FIGURE 4

Directions: Align the horizontal center line of the object below with drafting machine. Tape down. Construct the runouts. Do not erase construction lines.

Problem:



CONSTRUCT A POINT IN AN ORTHOGRAPHIC VIEW

Premise: A point in space has position but no extension such as the intersections of two lines. Three dimensions are necessary to fix its position in space. The procedure for the orthographic projection of one point will be used in the following example.

Example:

1. Use given point A in two views (Figure 1)
2. Project perpendicular lines from point A to reference lines RL1 and RL2 (Figure 1)

   NOTE: Light projected lines perpendicular to reference lines should be used to align the projections.
3. Construct mitre line to project depth dimension from top to right side or right side to top (Figure 1)

   NOTE: This is needed only to establish position in top view or right side view.
4. Project point S_{AT} and A_F to intersect in right side view to establish point in third view (Figure 2)

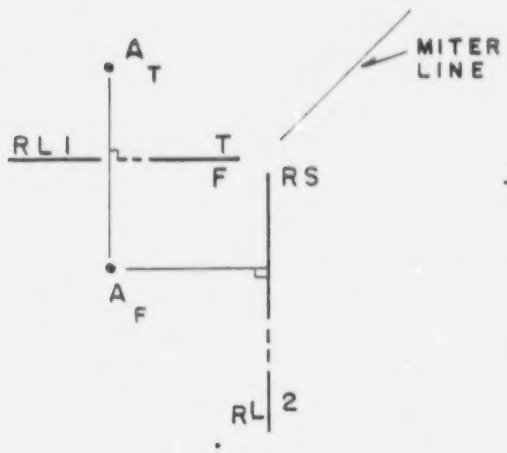


FIGURE 1

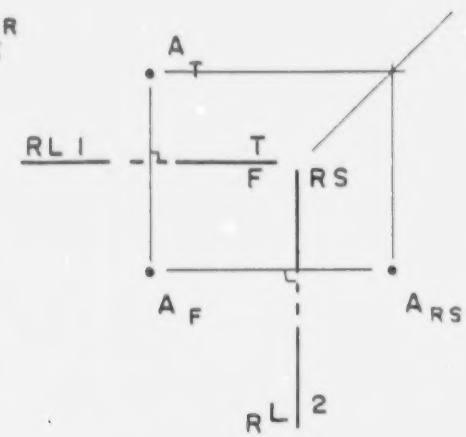
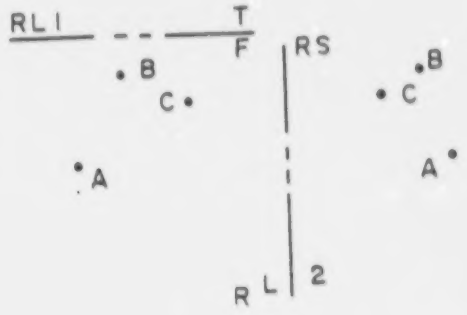


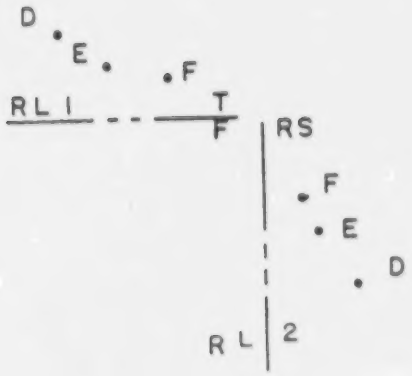
FIGURE 2

Directions: Align drafting machine with reference line and tape down for the following problems. Leave construction lines. Construct the points in the third view. Label points in third view.

Problem A:



Problem B:



CONSTRUCT A LINE IN AN ORTHOGRAPHIC VIEW

Premise: Lines are grouped into types as normal, inclined, or oblique, depending on how they are positioned with relationship to the reference lines. The procedure in the following example for oblique lines can be used for inclined or normal lines.

Example:

1. Use given line AB in two views (Figure 1)

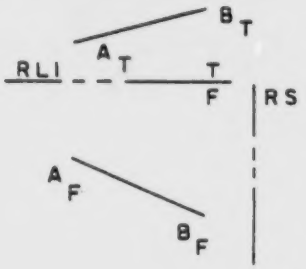


FIGURE 1

2. Project perpendicular lines from points A and B to reference lines RL1 and RL2 (Figure 2)

3. Construct mitre line to project depth dimensions from top to right side or right side to top view (Figure 2)

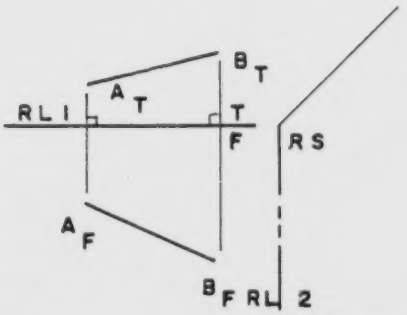


FIGURE 2

4. Project points A_T, B_T, and A_F, B_F to right side view, locating points A_{RS}, B_{RS} (Figure 3)

5. Connect points A_{RS}, B_{RS} with a line (Figure 4)

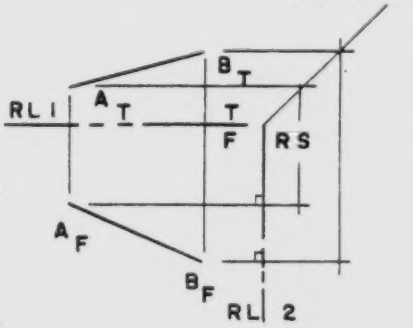


FIGURE 3

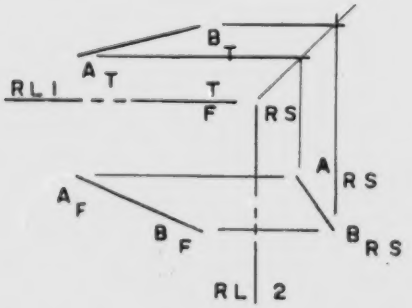
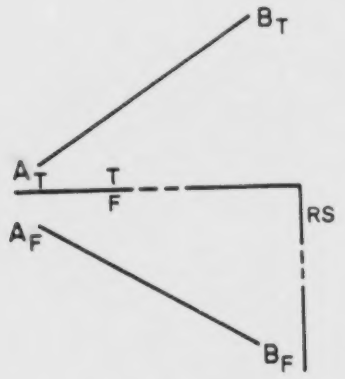


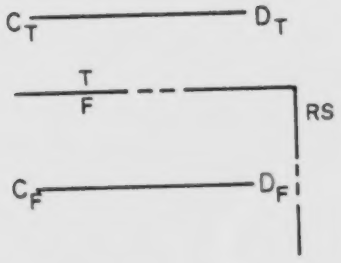
FIGURE 4

Directions: Align drafting machine with reference line and tape sheet down. Construct the third view of the line or lines given in the space provided.

Problem A:

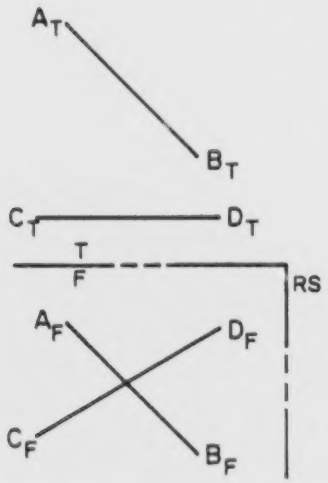


Problem B:

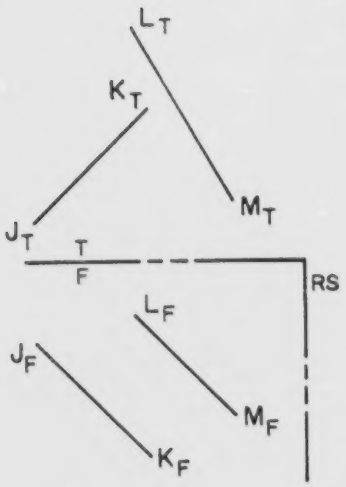


108

Problem C:



Problem D:



CONSTRUCT A PLANE IN AN ORTHOGRAPHIC VIEW

Premise: Planes are without thickness. A plane may be constructed by intersecting lines, two parallel lines, a line and a point, three points, or a triangle. The procedure in the following example is for constructing the third view when two views are given.

Example:

1. Use given plane ABC in two views (Figure 1)

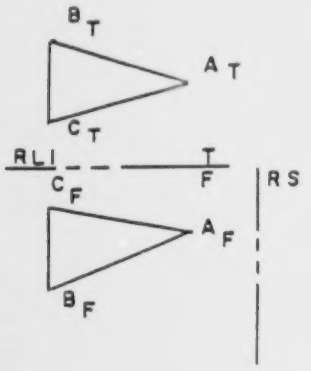


FIGURE 1

2. Project perpendicular lines from points A, B, and C, to reference lines RL1 and RL2 (Figure 2)

3. Construct mitre line to project depth dimension from top to right side or right side to top view (Figure 2)

4. Project points A_T, B_T, C_T, and A_F, B_F, C_T, to right side view, locating points A_{RS}, B_{RS}, C_{RS} (Figure 3)

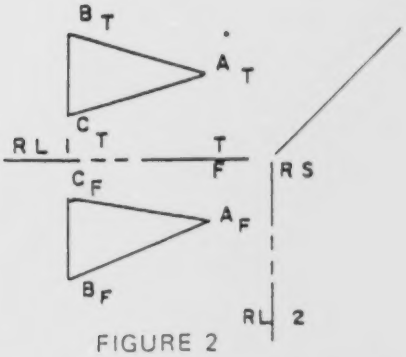


FIGURE 2

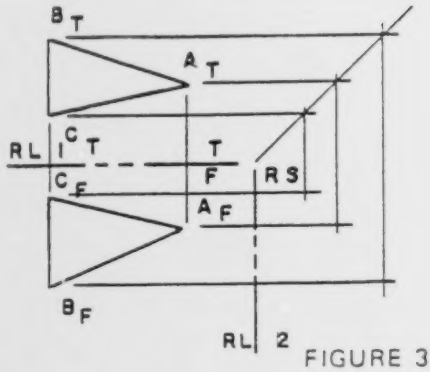
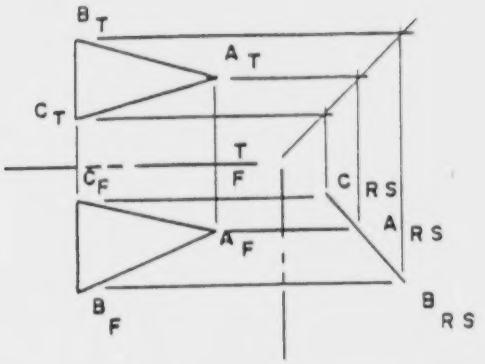


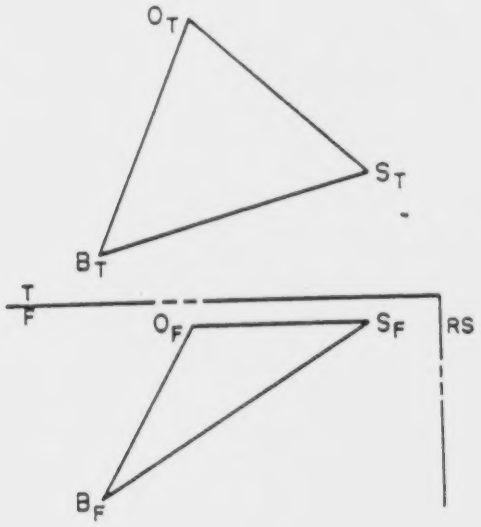
FIGURE 3

5. Connect points A_{RS}, B_{RS}, C_{RS} with lines to form plane (Figure 4)

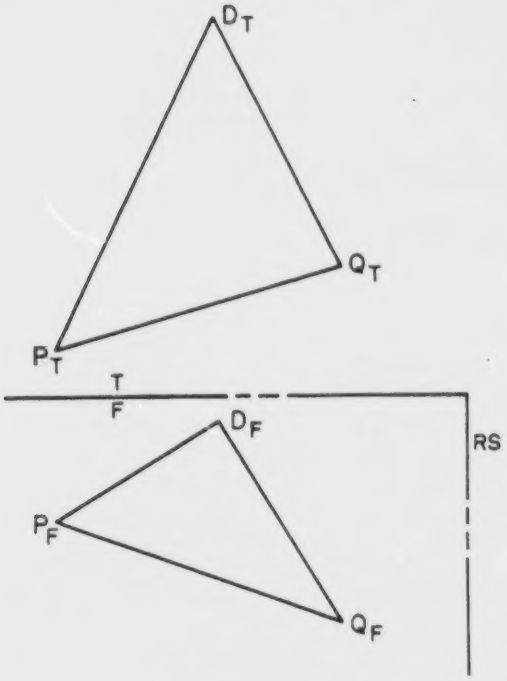


Directions: Align drafting machine with reference line and tape sheet down. Construct the third view of the plane given in the space provided.

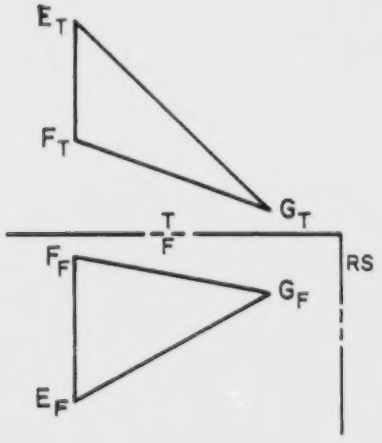
Problem A:



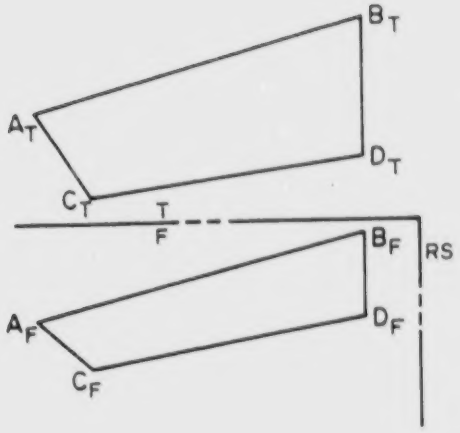
Problem B:



Problem C:



Problem D:



ANSWERS TO ASSIGNMENTS SHEETS

AS 1.1

A.

	PLANE TYPE
A	Normal
B	Normal
C	Normal
D	Normal
E	Normal
F	Inclined
G	Inclined

B.

	PLANE TYPE
A	Normal
B	Normal
C	Normal
D	Inclined
E	Oblique
F	Oblique
G	Normal

AS 1.2

A.

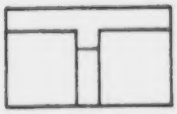
Line	Top	Front	R.Side
1	TL	Point	TL
2	TL	Point	TL
3	FS	TL	FS
4	TL	FS	FS
5	TL	TL	Point
6	Point	TL	TL
7	TL	Point	TL
8	Point	TL	TL
9	FS	TL	FS

B.

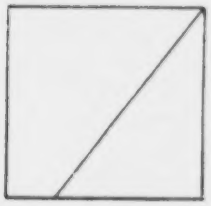
Line	Top	Front	R.Side
1	TL	TL	Point
2	FS	FS	FS
3	FS	FS	FS
4	TL	Point	TL
5	TL	FS	FS
6	TL	TL	Point
7	TL	FS	FS
8	TL	FS	FS
9	FS	FS	FS

AS 1.3

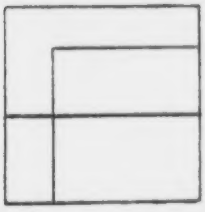
A.



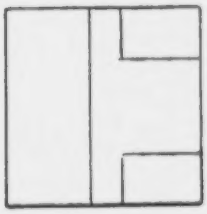
B.



C.

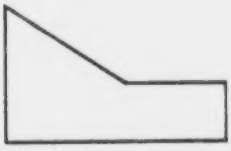


D.



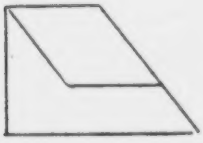
AS 1.4

A.



B.

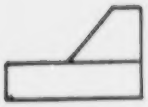
C.



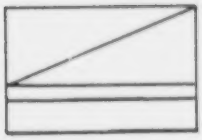
D.

AS 1.5

A.

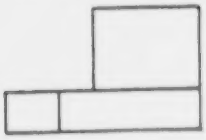


B.



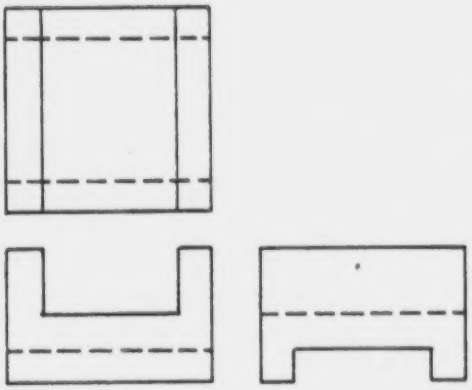
C.

D.

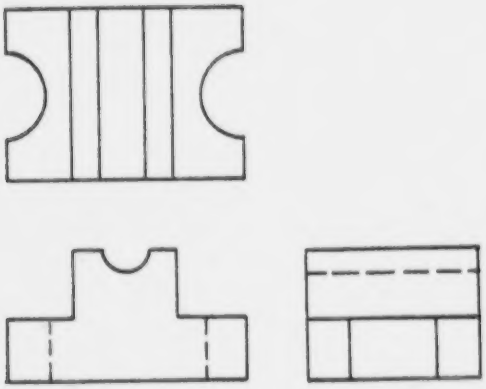


AS 1.6

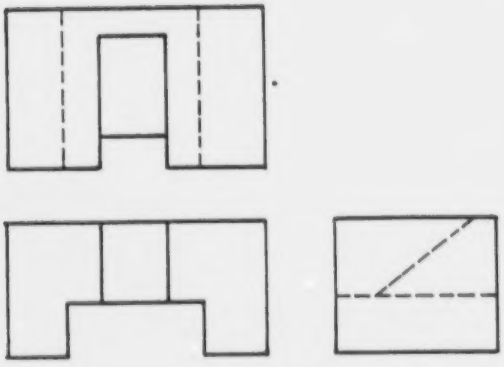
A.



B.



C.



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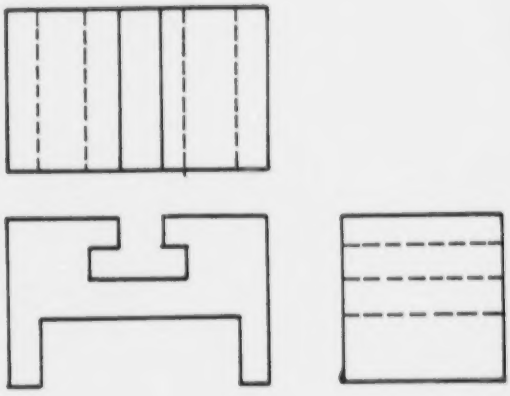
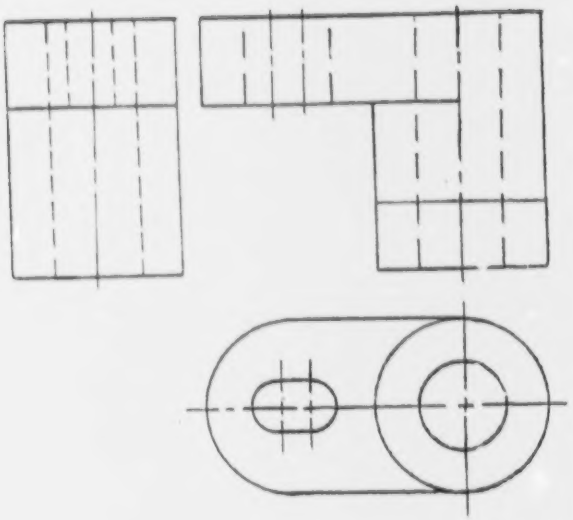


AS 1.7

A.



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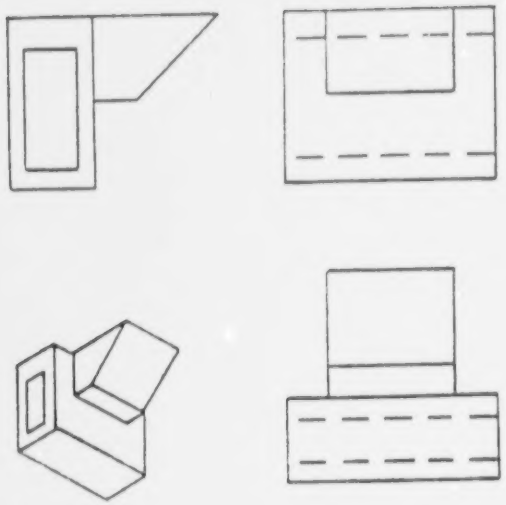

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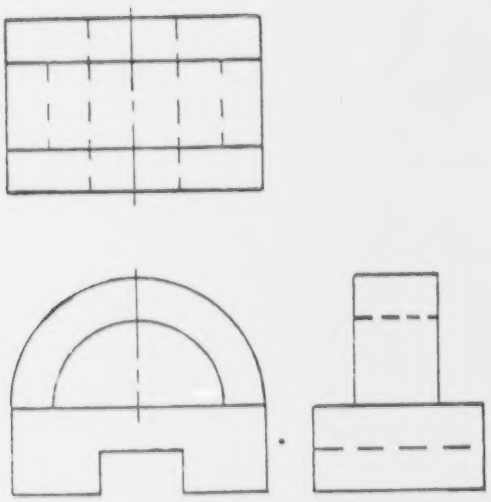

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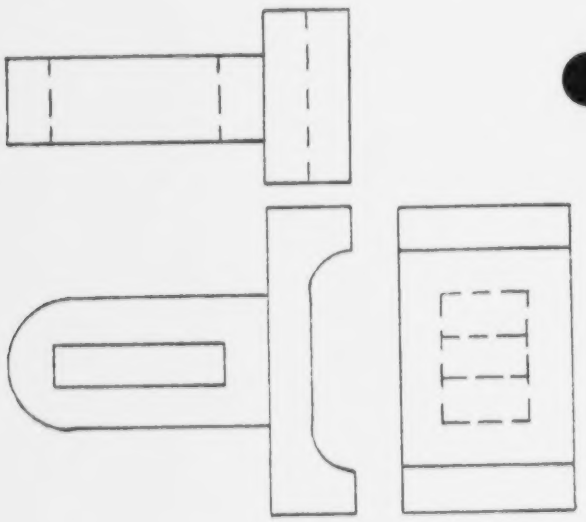

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AS 1.7

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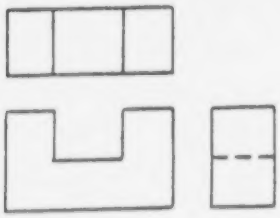

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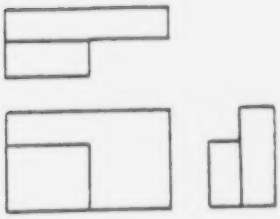

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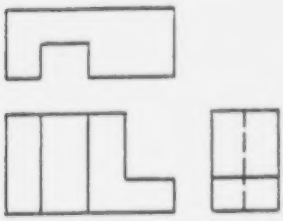

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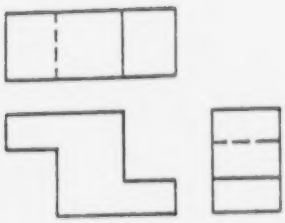

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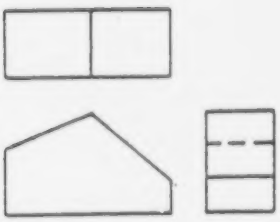

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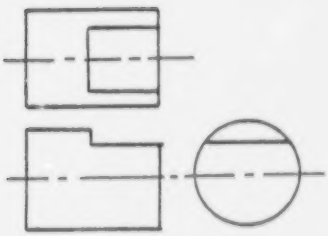

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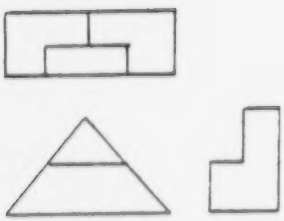

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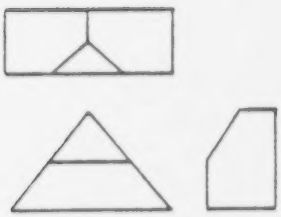

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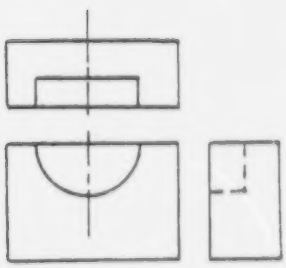

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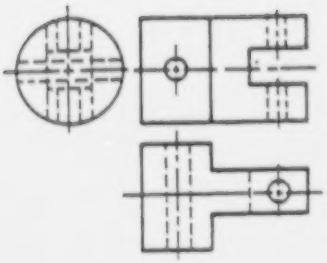

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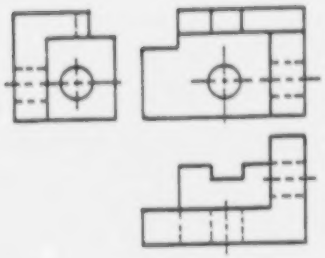

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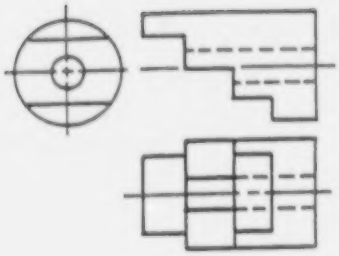
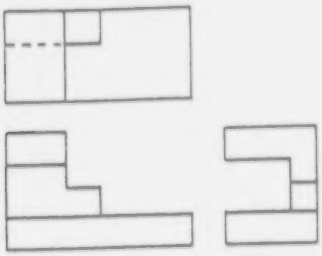


AS 1.8, 1.9

Evaluated to satisfaction of the instructor

AS 1.10

A.



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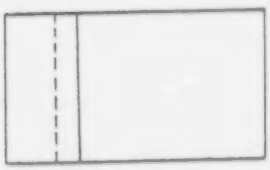
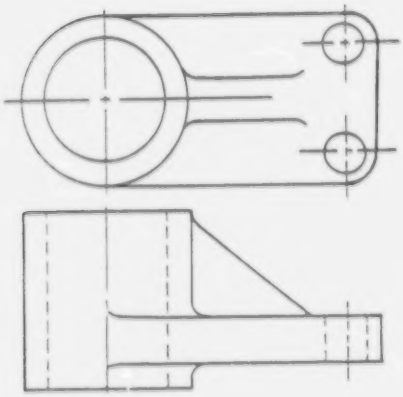


AS 1.11



AS 1.12

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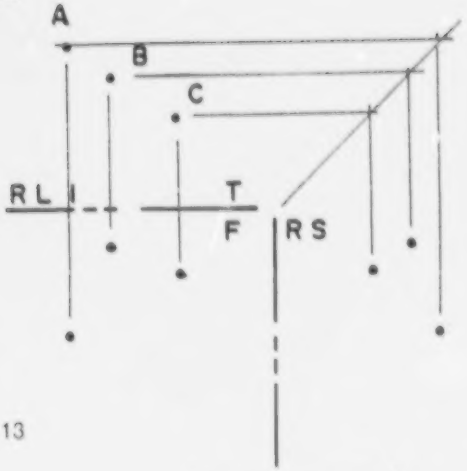

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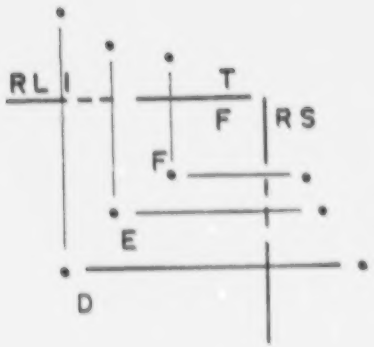

AS 1.13

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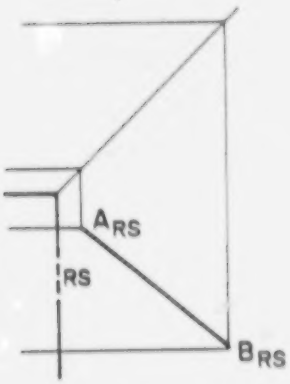

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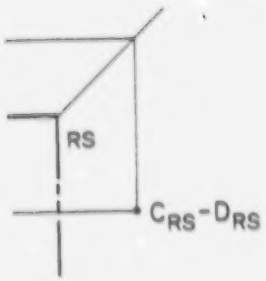

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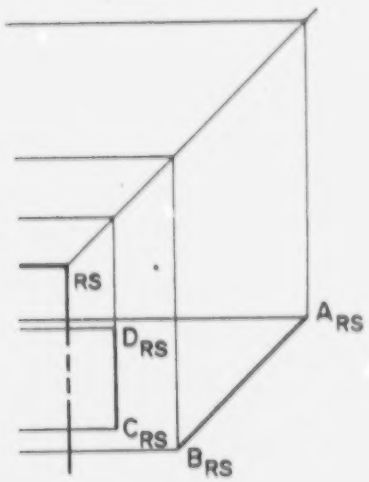

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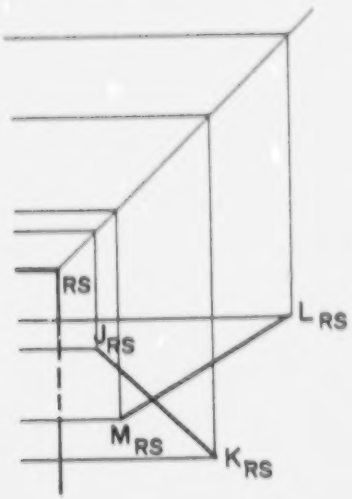
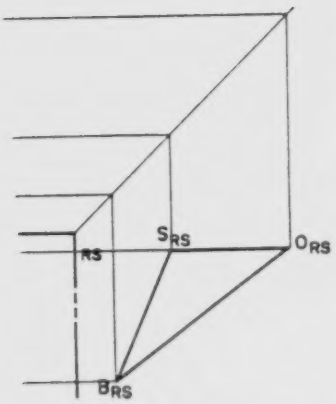


AS 1.14

A.



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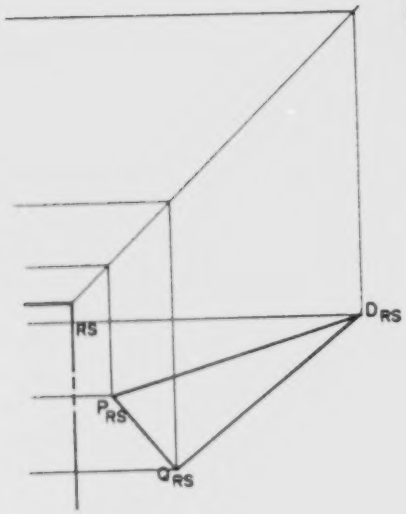

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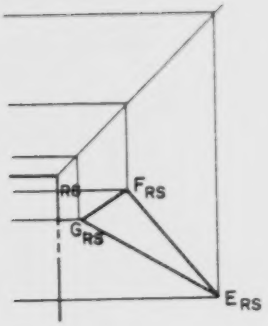

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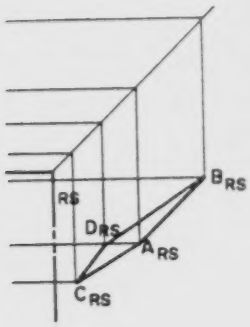


MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT I: ORTHOGRAPHIC VIEWS

UNIT TEST

Match the terms on the right with their correct definitions on the left.

___	1.	Method of representing the exact shape of an object in two or more views on planes at right angles to each other	a. Frontal view
___	2.	All views are projected onto planes located behind the object	b. Oblique plane
___	3.	All views are projected onto planes lying between the object and viewer	c. Width
___	4.	Lines used to extend from one view to the next view	d. First-angle projection
___	5.	Distance from bottom to top plane	e. Visualize
___	6.	Distance from left to right plane	ab. Projection lines
___	7.	Distance from front to back plane	ac. Height
___	8.	True size plane that is parallel to one principal viewing planes and edge view in one other principal viewing plane	ad. Foreshortened
___	9.	A plane that is foreshortened in two principal viewing planes and edge view in one other principal viewing plane	ae. Orthographic projection
___	10.	A plane that is foreshortened in all three principal viewing planes	bc. Inclined plane
___	11.	To appear shorter to the eye than it actually is	bd. Third-angle projection
___	12.	To form a mental picture or image	be. Depth
___	13.	Front view	cd. Normal plane

Match the terms on the right with their correct definitions on the left.

___	14.	Left side or right side view	a. Skew lines
___	15.	Top view	b. Fold line
___	16.	A surface or line that is shown in its actual size	c. Horizontal view
___	17.	A theoretical line between two views where viewing planes fold	d. Line
___	18.	Direction from which an object is being viewed	e. Round
___	19.	Take from one point of view and put in another view	ab. Profile view
___	20.	To match up identically	ac. Fillet
___	21.	Lines that are more important to show than others	ad. Coincide
___	22.	Nonintersecting lines, not parallel to each other or to the principal views	ae. Runout
___	23.	Intersection of a fillet or round with another surface	bc. Line precedence
___	24.	Small rounded inside corner of an object	bd. True size
___	25.	Small rounded outside corner of an object	be. Line of sight
___	26.	Straight element that is generated by a moving point and has extension only along the path of the point	cd. Transfer

___ 27. **Distinguish between the types of projection systems by placing the letter of the type used in the United States in the blank.**

a. First-angle

b. Third-angle

Mark an "a" for true statements concerning the steps in selecting correct views of an object. Mark a "b" for false statements.

___ 28. Select view necessary to best describe contour shape in right side view

___ 29. Select the view that contains the greatest number of hidden lines

___ 30. Select only needed views necessary to present an understanding of an object

___ 31. If there is not other option, select the view that best describes the object

___ 32. Select view positions to avoid crowding of dimensions and notes

Select correct line precedence in an orthographic drawing by placing the correct letter in the blank for each of the following pairs.

___ 33. a. center line

b. visible line

___ 34. a. cutting plane line

b. center line

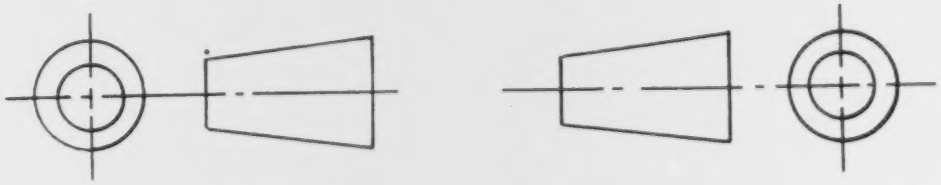
___ 35. a. visible line

b. hidden line

___ 36. a. center line

b. hidden line

Identify the ISO projection symbols.



37. _____ 38. _____

39. **List the six views possible in orthographic projection.**

a. _____ d. _____

b. _____ e. _____

c. _____ f. _____

40. **List the three most commonly used views in orthographic projection.**

a. _____

b. _____

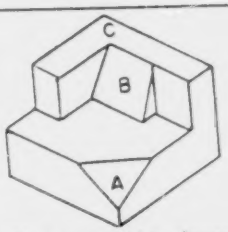
c. _____

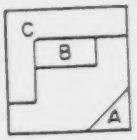
41. **Identify types of planes.**

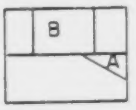
a. A planes _____

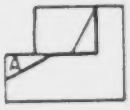
b. B planes _____

c. C planes _____



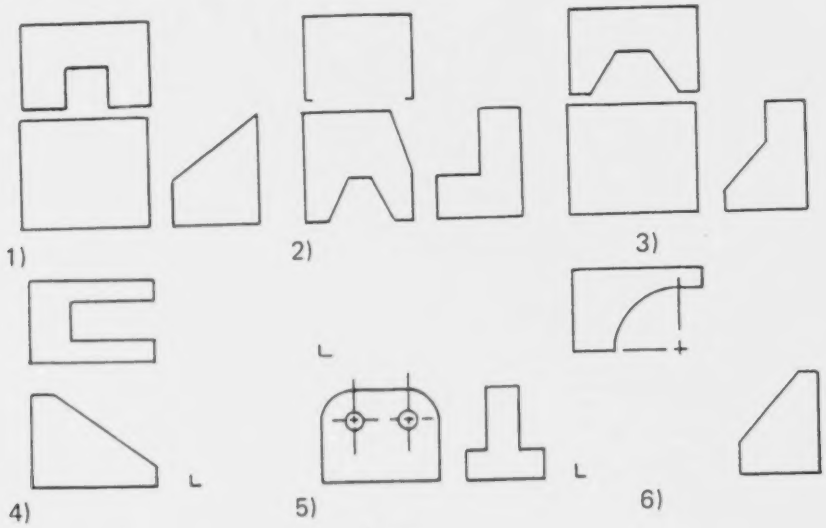




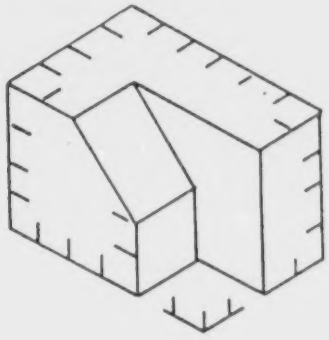


42. **Construct various orthographic drawings.**

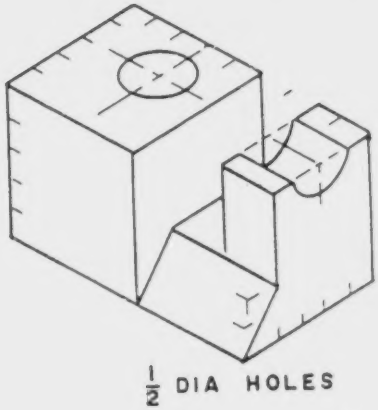
a. Complete the missing lines and views.



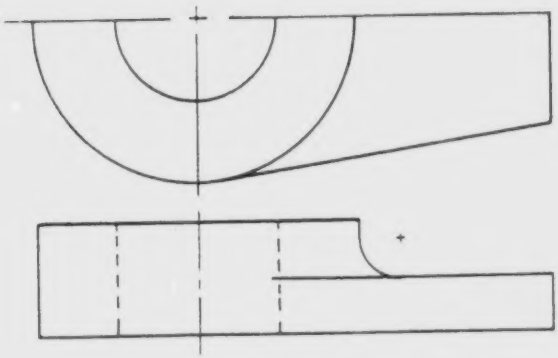
b. Construct three views of the object full size shown in pictorial. Begin the views using the corners given. Each mark is equal to 1/4".



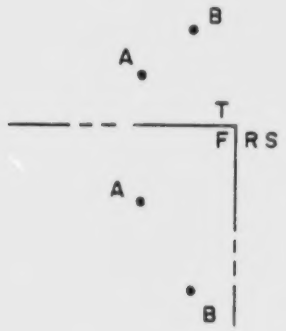
c. Construct three views of the object full size shown in pictorial. Each mark is equal to 1/4".



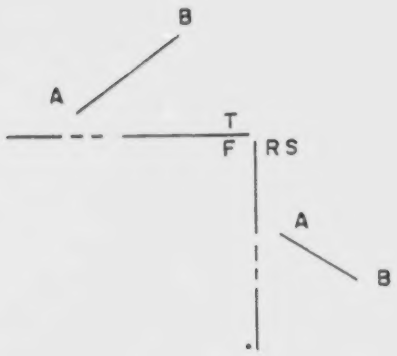
d. Construct a runout. Leave construction lines.



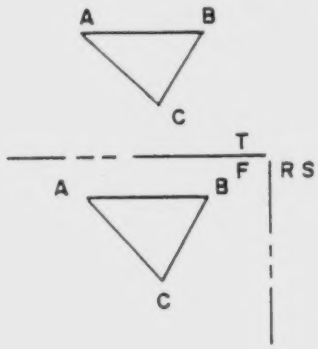
e. Construct points A and B in right side view.



f. Construct line as in front view.



g. Construct plane ABC in right side view.

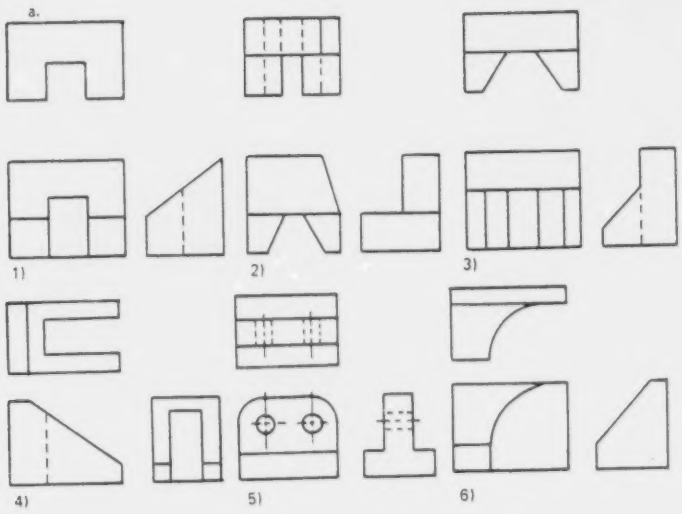


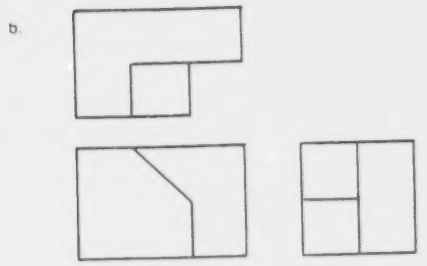
ANSWERS TO UNIT I TEST

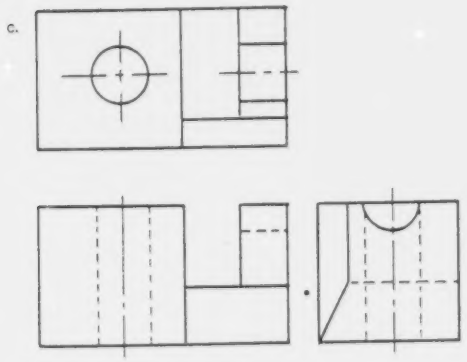
1. ae (E-1)
2. d (E-1)
3. bd (E-1)
4. ab (E-1)
5. ac (E-1)
6. c (E-1)
7. be (E-1)
8. cd (E-1)
9. bc (E-1)
10. b (E-1)
11. ad (E-1)
12. e (E-1)
13. a (E-1)
14. ab (E-1)
15. c (E-1)
16. bd (E-1)
17. b (E-1)
18. be (E-1)
19. cd (E-1)
20. ad (E-1)
21. bc (E-1)
22. a (E-1)
23. ae (E-1)
24. ac (E-1)
25. e (E-1)
26. d (E-1)
27. b (E-4)
28. b (E-2,3)
29. b (E-2,3)
30. a (E-2,3)
31. a (E-2,3)
32. a (E-2,3)
33. b (E-1,2,3)
34. a (E-1,2,3)
35. a (E-1,2,3)
36. b (E-1,2,3)
37. Third-angle (E-5)
38. First-angle (E-5)
39. The following in any order: (E-1)
    a. Top
    b. Front
    c. Right side
    d. Left
    e. Bottom
    f. Rear
40. The following in any order: (E-1)
    a. Top
    b. Front
    c. Right side
41. (E-1)
    a. Oblique
    b. Inclined

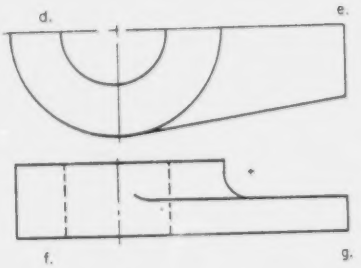
c. Normal

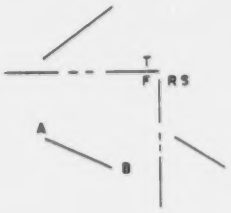
42. (E-1,2,3)

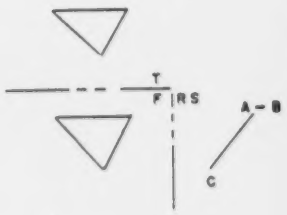












MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT II: DIMENSIONING

UNIT OBJECTIVE

After completion of this unit, the student should be able to relate dimensioning to correct size, shape, and location and be able to identify lines and correct line placement. The student should also be able to relate dimensions to their purposes, and draw various illustrations that show how to apply the rules of dimensioning properly. This knowledge will be evidenced by correctly performing the procedures outlined in the assignment sheets and by scoring __ percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1.1 Match terms related to dimensioning procedures with their correct definitions.

1.2 Distinguish between size description and shape description.

1.3 Differentiate between the types of dimensions.

1.4 Match the systems of placing dimensions with their correct definitions.

1.5 Match common abbreviations with their correct meanings.

1.6 Name and define three systems of writing dimensional values.

1.7 Identify four basic types of lines used in dimensioning.

1.8 Select true statements concerning rules for lines used in dimensioning.

1.9 Differentiate between correct and incorrect placement of leader lines.

1.10 State how to draw arrowheads.

1.11 List two rules concerning arrowheads.

1.12 Select true statements concerning rules for dimensional figures.

1.13 Select true statements concerning rules for placement of dimensions.

1.14 Arrange in order the steps in applying dimensions to an object.

1.15 State the purpose for a notation on a drawing.

1.16 Select true statements concerning rules for notations.

1.17 Name and define the two types of notes used on a drawing.

1.18 Select true statements concerning methods of dimensioning arcs.

1.19 Draw an illustration that shows how to correctly dimension angles.

1.20 Draw an illustration that shows how to correctly dimension curves.

1.21 Draw an illustration that shows how to correctly dimension rounded end shapes.

1.22 Draw an illustration that shows how to correctly dimension a spherical object.

1.23 Draw an illustration that shows how to correctly dimension cylindrical objects.

1.24 Draw an illustration that shows how to correctly dimension features on a circular center line.

1.25 Draw an illustration that shows how to correctly dimension a theoretical point of intersection.

1.26 State two reasons for avoiding superfluous dimensions.

1.27 List ways to avoid superfluous dimensions.

1.28 Draw an illustration that shows how to dimension an object using a selected coordinate system.

1.29 Demonstrate the ability to:

a. Construct arrowheads

b. Dimension arcs.

c. Dimension angles.

d. Dimension curves.

e. Dimension rounded end shapes.

f. Dimension spherical objects.

g. Dimension cylindrical objects.

h. Dimension cones, pyramids, and prisms.

i. Dimension features on a circular center line.

j. Dimension a theoretical point of intersection.

k. Dimension an object using a rectangular coordinate system.

l. Dimension an object using a polar coordinate system.

m. Dimension an object using a tabular coordinate system.

n. Dimension an object using an ordinate dimensioning system.

MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONS

UNIT II: DIMENSIONING

CONTENTS OF THIS UNIT

A. Objective sheet

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1. Lesson 1: DIMENSIONING PROCEDURES

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TM 1.2:	Aligned System
TM 1.3:	Unidirectional System
TM 1.4:	Types of Lines
TM 1.5:	Rules for Lines
TM 1.6:	Arrowheads
TM 1.7:	Rules for Figures
TM 1.8:	Placement of Dimensions
TM 1.9:	Placement of Leaders
TM 1.10:	Dimensioning Prisms and Feature Locations
TM 1.10A	Dimensioning Prisms and Feature Locations (Continued)
TM 1.11:	Dimensioning Angles
TM 1.12:	Dimensioning Cylindrical Objects
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19A--Overlay	
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TM 1.20:	Superfluous Dimensions
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TM 1.22:	Superfluous Dimensions (Continued)

c. Assignment sheets

AS 1.1:	Dimension Prisms and Feature Locations
AS 1.2:	Dimension Angles
AS 1.3:	Dimension Cylindrical Objects

AS 1.4:	Dimension Spherical Objects
AS 1.5:	Dimension Pyramids and Cones
AS 1.6:	Dimension Arcs
AS 1.7:	Dimension Rounded End Shapes
AS 1.8:	Dimension Features on a Circular Center Line
AS 1.9:	Dimension Curves
AS 1.10:	Dimension an Object Using a Rectangular Coordinate System
AS 1.11:	Dimension an Object Using a Polar Coordinate System
AS 1.12:	Dimension an Object Using a Tabular Coordinate System
AS 1.13:	Dimension an Object Using an Ordinate Dimensioning System

D. Answers to assignment sheets

E. Unit test

F. Answers to unit test

REFERENCES

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2. Davis, Ronald, Bill Hill, and Bruce Yancey. Basic Drafting: Book Two. Stillwater, Okla., 74074: Mid-American Vocational Curriculum Consortium, Inc., 1981.

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8. Wallach, Paul Ross and Dean Chowenhill. Drafting in a Computer Age. Albany, N. Y.: Delmar Publishers, Inc., 1989.

9. American Society of Mechanical Engineers. American National Standard, Engineering Drawing and Related Documentation Practices. ANSI Y14.5M, 1982, New York, N. Y., 1983.

10. American Scoeity of Mechanical Engineers. Multi and Sectional View Drawing, ANSI Y14.3, 1975, New York, N.Y., reaffirmed, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Copies of the ANSI standards can be purchased from the American Society of Mechanical Engineers, 22 Law Drive, Box 2300, Fairfield, NJ 07004. A catalog with pricing is available.

2. Have file drawings or working drawings available to demonstrate dimensioning to the class.

MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT II: DIMENSIONING

LESSON 1: DIMENSIONING PROCEDURES

I. Terms and definitions

A. **Actual size**--measured size of a complete object

B. **Bevel**--slanted flat surface not at 90° to another surface

C. **Blind hole**--a hole not drilled all the way through

D. **Boss**--a raised flat, cylindrical surface providing a flat surface for bolts

E. **Chamfer**--a slight bevel removed from an edge

F. **Datum**--points, lines, or other geometric shapes assumed to be exact from which the location or geometric features of a part may be established

G. **Dimension**--a numerical value on a drawing (along with the lines, symbols, and notes) that defines the size or geometric controls (or both) of an object or part feature

H. **Feature**--physical portion of a part, usually a geometric shape or figure, such as a surface, hole, or slot

I. **Leader**--a line terminating with an arrowhead that is used to direct a dimension, note, to a specific feature or place on a drawing

J. **Nominal**--designated or theoretical size that may vary from the actual

K. **Radial**--moving along a radius

L. **Reference dimension (REF)**--a dimension used for information purposes only; it does not given production or inspection operations

M. **Superfluous**--exceeding what is sufficient or necessary

N. **Tabular**--set up in rows and columns, by means of a table

II. Dimensioning standards

A. The most commonly used standard in the United States for dimensioning and tolerancing is the American National Standard ANSI Y14.5M-1982.

NOTE: Procedures used in this module meet requirements of ANSI Y14.5-1982.

III. Size and shape description (TM 1.1)

A. Size description--the notes and dimensions that tell the size of an object

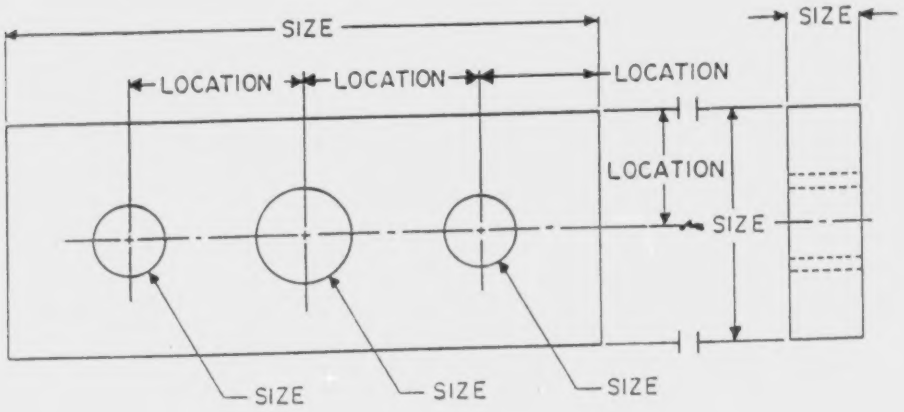
B. Shape description--the views that illustrate the shape of an object

IV. Types of dimensions (TM 1.1)

A. Size dimension--any type of dimension that tells how large or small an object is

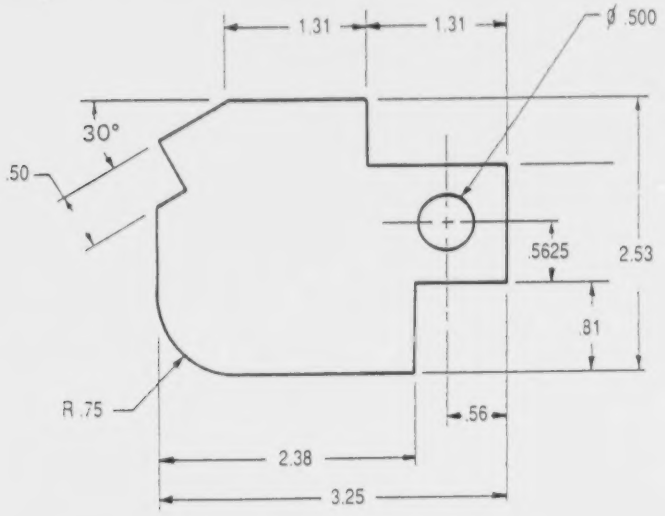
B. Location dimension--any type of dimension that locates a feature on an object

Example:

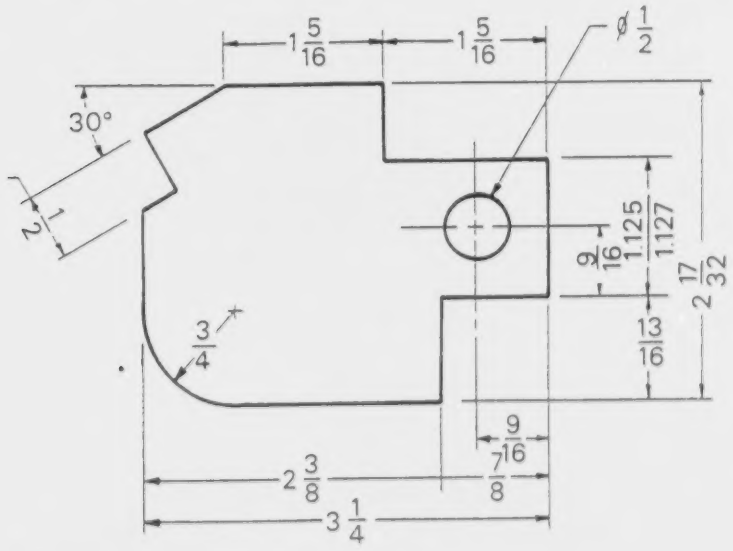


V. Systems of placing dimensions and definitions

A. Unidirectional system--a dimension figures and notes are lettered horizontally on the sheet and read from the bottom of the drawing (TM 1.2)



B. Aligned system--all dimension figures are aligned with the dimension lines so that they may be read from the bottom or from the right side of the sheet (TM 1.3)



NOTE: Dimensions and notes shown with leader lines are aligned with the bottom of the page.

VI. Systems of writing dimensional values and their definitions

A. Decimal--system of units and decimals used in production machine drawings where accuracy is required

NOTE: The decimal system is compatible with the calibrations of machine tool controls and numerically controlled machine tools.

B. Metric--system of units and decimals based on "The International System of Units," where the millimeter is the linear unit of measure

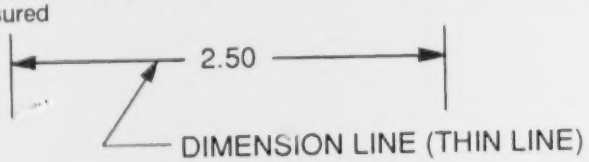
C. Fractional--system of units and common fractions used primarily in wood cabinet, furniture, and architectural structural work

NOTE: The fractional system should not be used for engineering drawings as it is no longer recognized as standard by ANSI Y14.5M-1982.

VII. Basic types of lines used in dimensioning (TM 1.4)

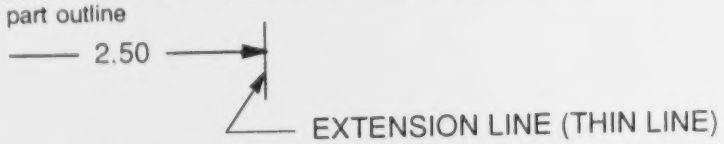
A. Dimension line--a line, with arrowheads, that shows the direction and length of what is being measured

Example:



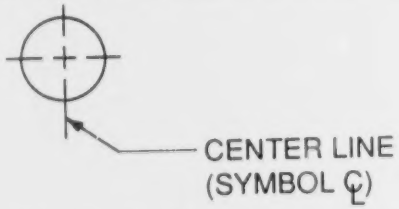
B. Extension line--a line used to indicate the extension of a surface or a point to a location outside the part outline

Example:



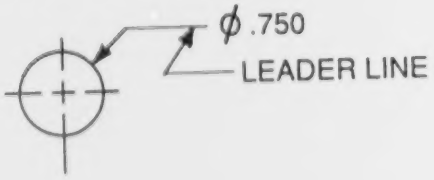
C. Center line--a line used to indicate the center of a cylindrical feature

Example:



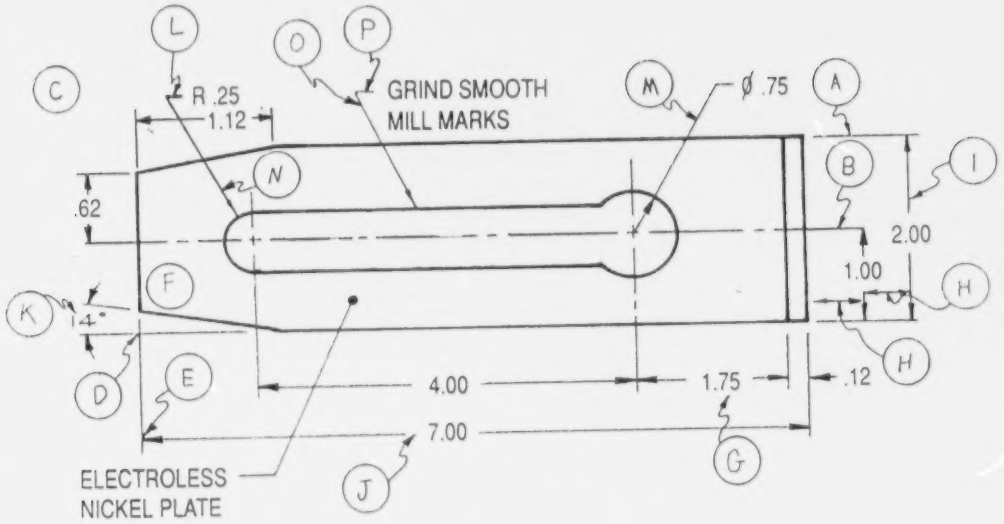
D. Leader line--a thin solid line that "leads" from a note or dimension and is terminated by an arrowhead touching the part to which attention is directed. It points to the center of the feature.

Example:



VIII. Rules for lines used in dimensioning (TM 1.5)

Example:



A. Extension lines show what is to be measured

B. Extension lines show the location of other details

C. Extension lines start or stop 1/16" away from visible lines and are extended approximately 1/8" beyond dimension lines

D. Extension lines may cross each other or visible lines without a break; extension lines may cross each other but they can never cross dimension lines

E. Extension lines are classified as thin lines

F. Center lines may be used as extension lines but never as dimension lines

G. Keep dimensions in line

H. Dimension lines should not be less than .40" (10mm) away from visible lines or .24" (6mm) away from each other

I. Dimension lines are classified as thin lines

J. Except in architectural and structural drafting, dimension lines are broken to allow space for the dimension

K. Dimension lines are drawn as arcs to show angular measurement; the center of the arc is the vertex of the angle.

L. A horizontal "shoulder" approximately 1/8" long should extend from end of leader

M. Leaders are usually drawn at a 45°, 30°, or 60° angle to the horizontal, but never vertical or horizontal

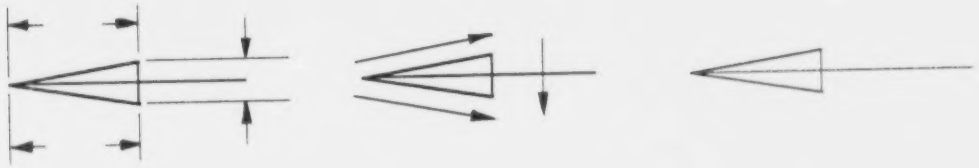
N. Normally, a leader terminates in an arrowhead; however, where it is intended for a leader to make reference to a surface by ending within the outline of that surface, the leader should terminate in a dot

O. Leaders should extend past the visible lines to keep the dimensions of notes off the object; leaders and notes should be added last so that a neat drawing will result

P. A leader always points toward the center of the top line of a note

IX. How to draw arrowheads--arrowheads are drawn with two sharp strokes toward or away from the point; length will vary depending on size of drawing, but width should always be 1/3 of the length (TM 1.6)

Example:



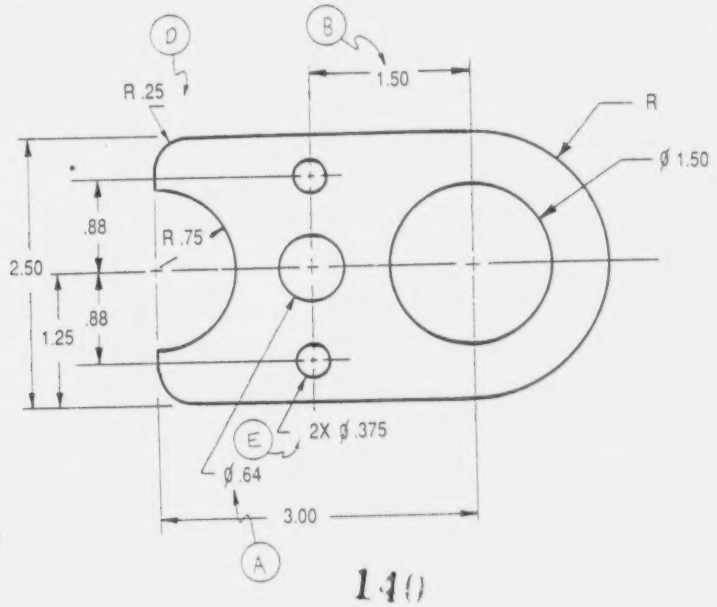
X. Rules concerning placement of arrowheads (TM 1.6)

A. Arrowheads always touch extension lines

B. Arrowheads are reversed when space for the dimension is too small

XI. Rules for dimensional figures (TM 1.7)

Example:



A. All lettering, letters, and numerals must be perfectly legible.

B. Numerals should be large enough to be easily read; standard height is 1/8" (the same height as letters)

C. Never letter a dimension figure over any line on the drawing; break the line if necessary

D. Make all decimal points bold

E. Inch marks (") are omitted unless a dimension may be misunderstood; thus, 1.00" should be written 1.00

F. In general, a circle is dimensioned by its diameter, an arc by its radius; The diameter symbol (ϕ) should be used on all diameter dimensions

G. Fractions are two times the height of whole numbers

H. The fraction bar is always in line with the dimension line; the fraction bar is never drawn at an angle

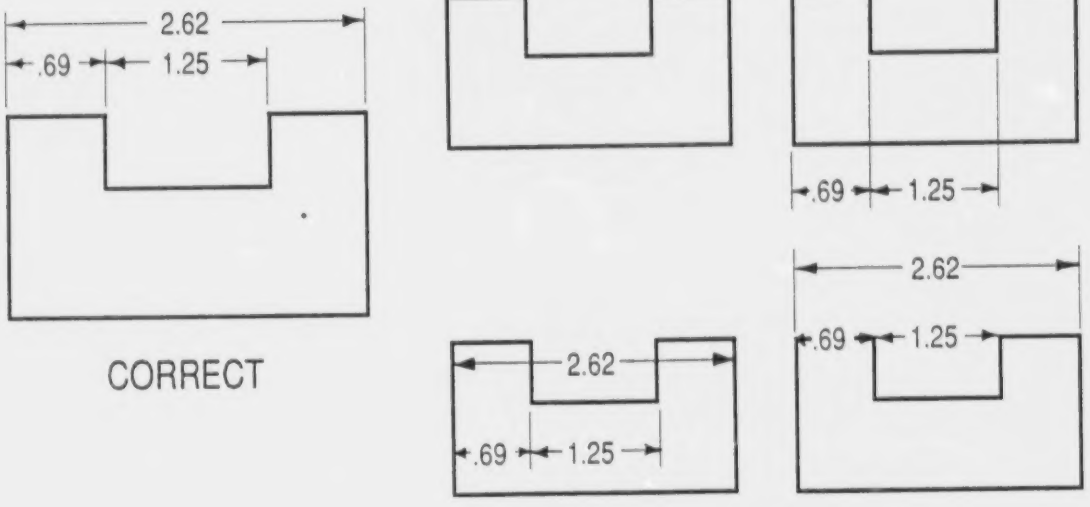
NOTE: An exception to this may be made in crowded places, such as parts lists, but never in dimensioning on a view.

I. The numerator and denominator of a fraction should never touch the fraction bar

J. In a group of parallel dimension lines, the numerals should be staggered, not stacked, one above the other

XII. Rules for placement of dimensions (TM 1.8)

Example:



A. Each dimension should be given clearly so that it can be interpreted in only one way

B. Dimensions should not be duplicated or the same information be given in two different ways, and no dimensions should be given except those needed to produce or inspect the part

C. Dimensions should be given between points or surfaces that have a functional relations to each other or that control the location of mating parts

D. Whenever possible, dimensions should be given to finished surfaces or important center lines in preference to rough surfaces

E. Dimensions should be so given that it will not be necessary for the machinist to calculate, scale, or assume any dimension

F. Dimensions should be attached to the view where the shape is best shown (contour rule)

G. Dimensions should be placed in the views where the features dimensioned are shown true shape

H. Wherever possible, avoid dimensioning to hidden lines wherever possible

I. Dimensions should not be placed upon a view unless clearness is promoted and long extension lines are avoided

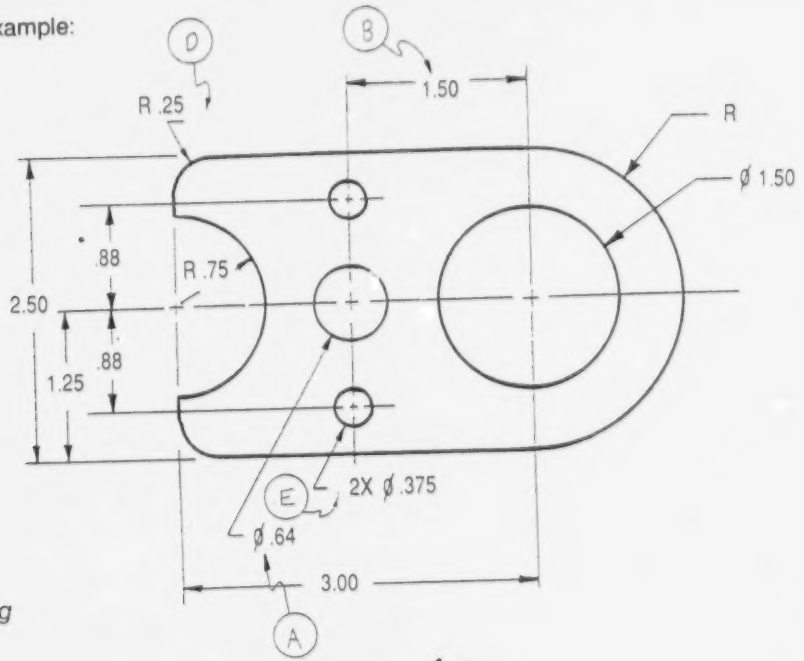
J. Dimensions applying to two adjacent views should be placed between views unless clearness is promoted by placing some of them outside

K. The longer dimensions should be placed outside all intermediate dimensions so that dimension lines will not cross extension lines

L. Do not expect the worker to assume that a feature is centered (as a hole on a plate), but give a location dimension from one side

M. Horizontal and vertical center lines may be used as reference (base) lines for dimensions

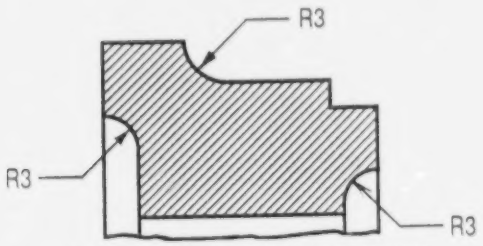
Example:



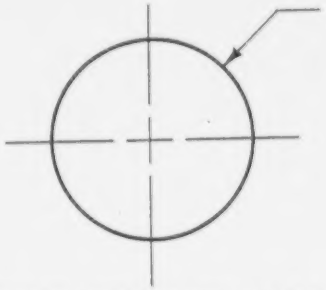
XIII. Correct placement of leader lines (TM 1.9)

A. Dimensions are specified individually to avoid complicated leaders

Example:



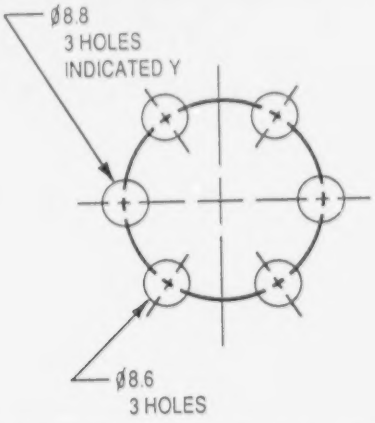
ONE LEADER FOR EACH FEATURE



LEADER DIMENSIONING HOLE SIZE

B. If too many leaders would impair the legibility of the drawing, letter symbols should be used to identify features

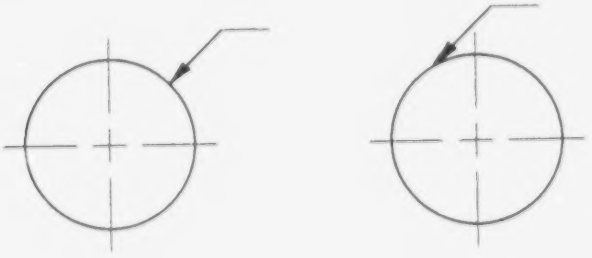
Example:



WHERE MANY LEADERS WOULD BE CONFUSING

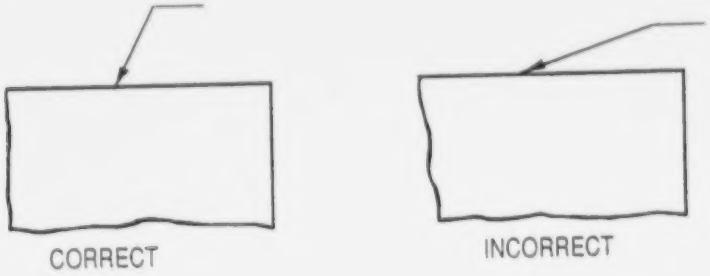
C. Where a leader is directed to a circle or arc, its direction should be toward the center

Example:



D. Avoid small angles between leaders and the lines where they terminate

Example:



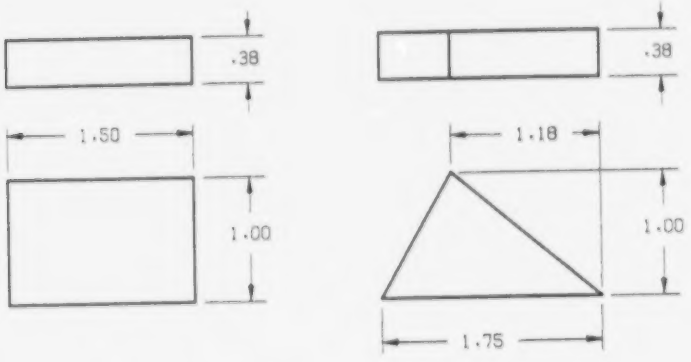
XIV. How to dimension prisms and feature locations (TM 1.10)

A. Prisms

1. Give the height, width, and depth

2. Two of the dimensions will be in one view and the third dimension will always be in the next view

Examples:



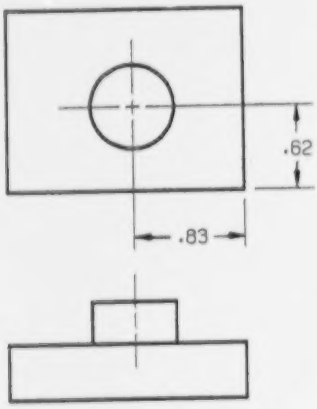
B. Rectangular objects are located by coordinate dimensions

C. Cylinders should be located by their center lines

D. Cylinders should be located in the circular views, if possible

E. Cylinders should be located by coordinate dimensions in preference to angular dimensions where accuracy is important

Example:



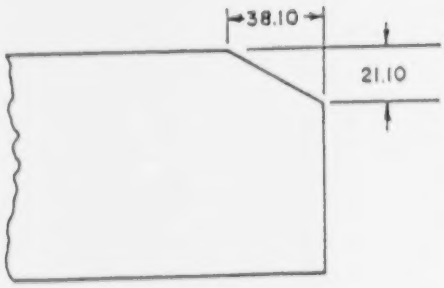
LOCATING CYLINDERS

XV. How to dimension angles correctly (TM 1.11)

A. By means of coordinate dimensions of the two legs of a right triangle

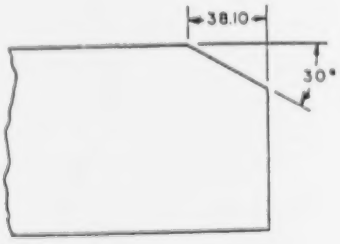
NOTE: Coordinate dimensions are preferred when a high degree of accuracy is required.

Example:



B. By means of a linear dimension and an angle in degrees

Example:



C. Variations of degrees and arrowhead placement should be as follows:

Example:

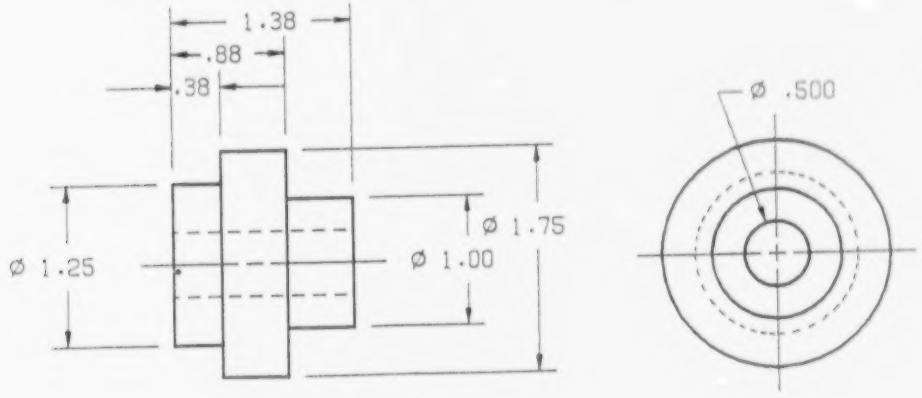
NOTE: The circular dimension lines are always drawn with the compass center at the vertex of the angle.

XVI. How to dimension cylindrical objects correctly--give both the diameter and the length in the rectangular view (TM 1.12)

A. Avoid diagonal diameters, except for very large holes and for circles of centers; they may be used on positive cylinders when clearness is gained thereby

NOTE: The radius of a cylinder should never be given.

Example:

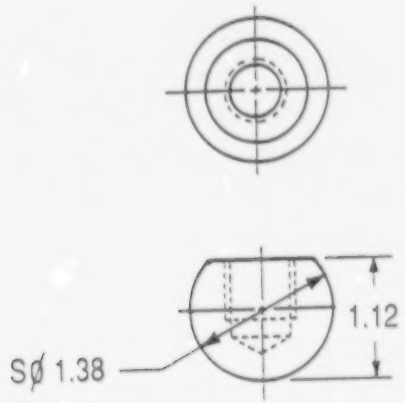


XVII. How to dimension a spherical object correctly (TM 1.13)

A. A spherical end is dimensioned by a radius, followed by "SPHERE R" (example a)

B. A sphere is dimensioned by giving its diameter (example b)

Examples:



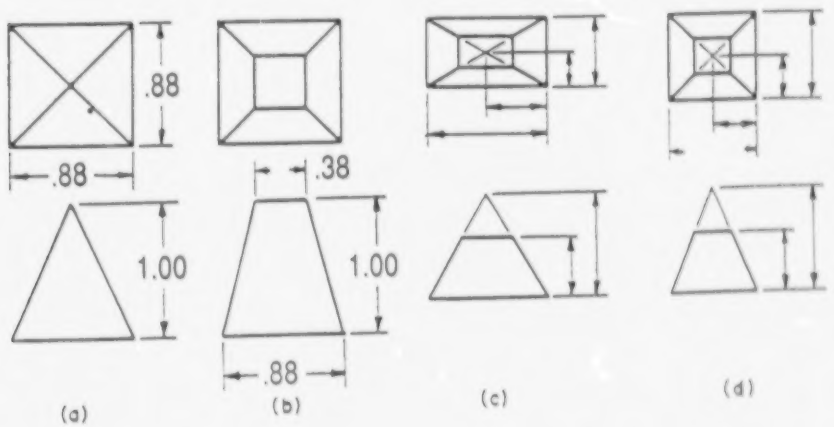
XVIII. How to dimension pyramids and cones correctly (TM 1.14)

A. Pyramids

1. Give dimensions of base in rectangular view and the height in the other view (example a)

2. Give dimensions of base and locate center point in rectangular view and give height in the other view (example b)

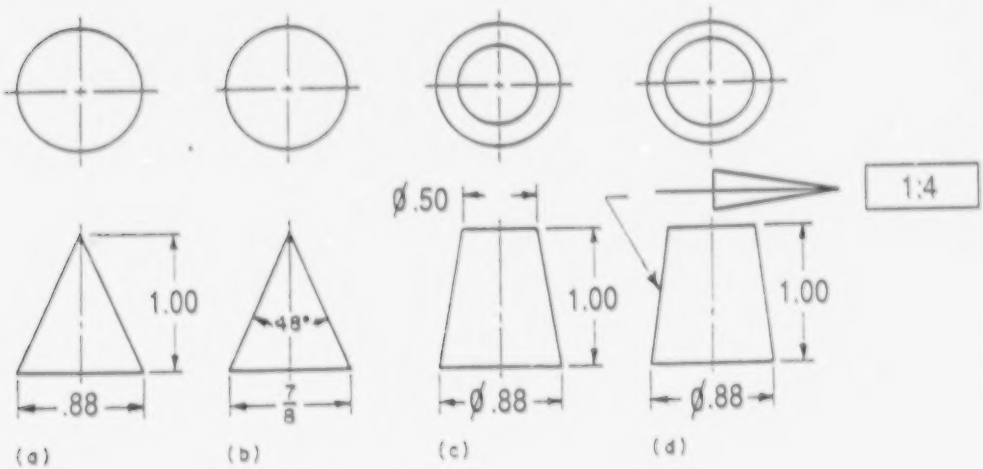
Examples:



B. Cones

1. Diameter and height in the triangular view (example a)
2. Diameter and the angle (example b)
3. Give two diameters and the height (example c)
4. Diameter of large end, and the height and the taper (example d)

Examples:



NOTE: The appropriate method to use depends on the accuracy required and the process that will be used to make the cone.

XIX. Methods of dimensioning arcs in available spaces (TM 1.15)

A. An arc is dimensioned in the view in which its true shape is shown

B. The letter R should always precede a radius dimension figure; the radial dimension line should have only one arrowhead, and it should pass through or point through the arc center and touch the arc

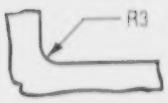
C. Most external arcs (rounds) can be located by their tangent points. Since they are difficult to make accurately, tight tolerances are seldom required

D. Fillets are easily made in machined parts, but difficult to make in cast parts; they are generally located by their tangent points, but sometimes are located by their center point, which would be indicated with a cross

E. When external arcs require precise center locations, the center is located by coordinate dimensions

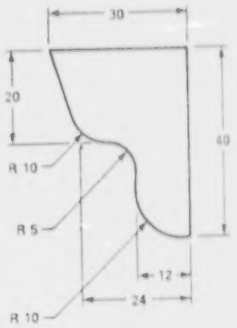
Example:

EXTERNAL ROUND

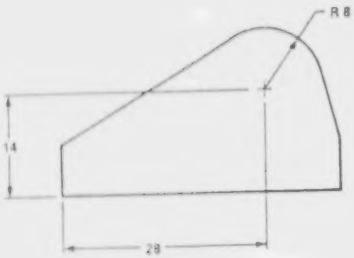


FILLET (SMALL)

FILLET (LARGE)



LOCATED BY TANGENT LINES



LOCATED BY COORDINATE DIMENSIONS

F. When there are several rough noncritical features obviously the same size such as fillets or rounds, it is necessary to give only typical dimensions or to use a note

G. For a long radius with center point outside available space, the dimension leader is drawn toward the actual center, but a false center is indicated and the dimension line is jogged to it

Example:

CENTER LOCATED OUTSIDE DRAWING

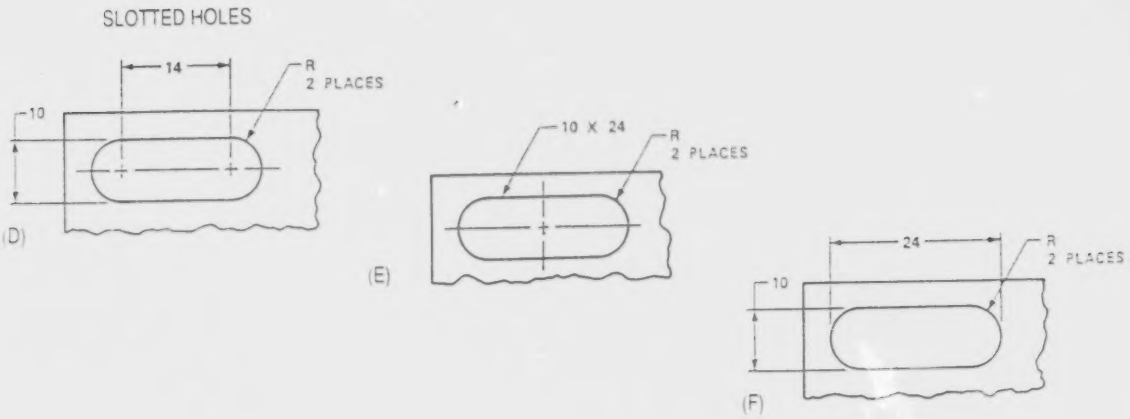
XX. How to dimension rounded end shapes correctly (TM 1.16)

A. For fully rounded objects, the length and the width are given; the radius symbol is shown, but the actual radius figure is not shown

B. When the object is not fully rounded, the radius figure must be given.

C. The radius figure is given for rounded corners

D. Slotted holes are dimensioned as shown in D, E, F



NOTE: This method is used when precision is required.

XXI. How to dimension features on a circular center line correctly (TM 1.17)

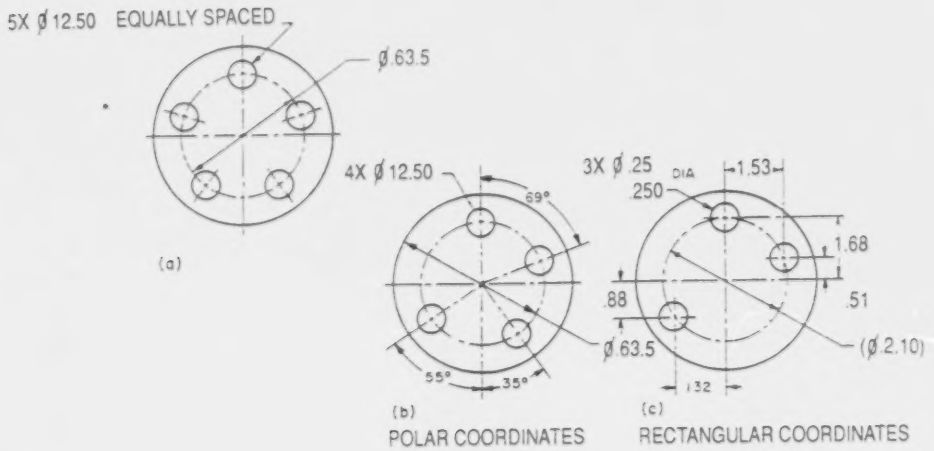
A. Holes equally spaced are dimensioned by giving the diameter of the center line or bolt circle and specifying "equally spaced" in a note (example a)

B. Holes unequally spaced are dimensioned by giving the diameter of the center line plus angular measurements with reference to one of the center lines (example b)

C. When precise accuracy is required, coordinate dimensions should be given using the center lines as datum lines (example c)

NOTE: Circular center line dimension will be enclosed in parentheses to indicate that it is to be used only as a reference dimension.

Examples:



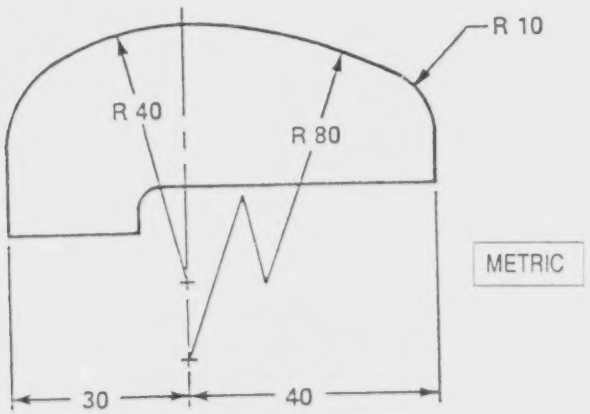
XXII. How to dimension curves correctly (TM 1.18)

A. Continuous curves made up of a series of circular arcs with known center points.

1. Dimension all arcs with leader lines

2. Locate all center points from each other and from some common datum point

Example:

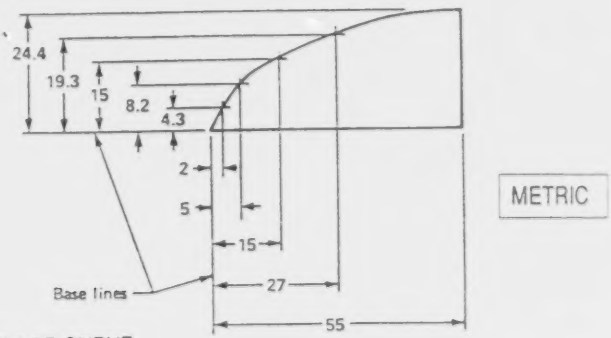


CURVES MADE FROM ARCS

NOTE: For extremely large radii, such as the 80 mm radius in the example above. The center may be drawn closer to the arc than actual size; the actual location dimension is still given though it is not to scale.

B. Irregular curves with unknown center points can be dimensioned by means of coordinate dimensions or from two datum base lines, a method which will provide a series of points which can be connected with an irregular curve

Example:



IRREGULAR CURVE

XXIII. Steps in applying dimensions to an object (TM 1.19)

A. Draw extension lines and extend the center lines of the hole to be used in the same manner as extension lines (Overlay 19A)

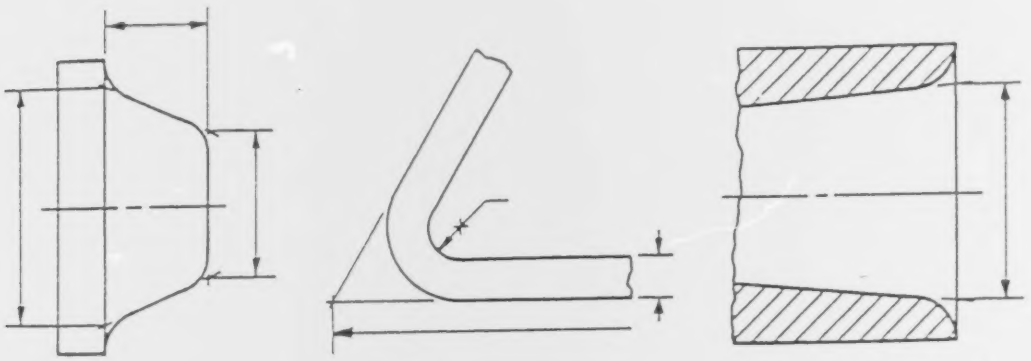
B. Use scale to measure dimension line locations with adequate space between each and gaps for dimension figures (Overlay 19B)

C. Draw in guidelines for figure

D. Letter in dimensions (Overlay 19C)

E. Draw in arrowheads (Overlay 19D)

XXIV. How to dimension a theoretical point of intersection--project extension lines until they cross, forming a point that can be dimensioned



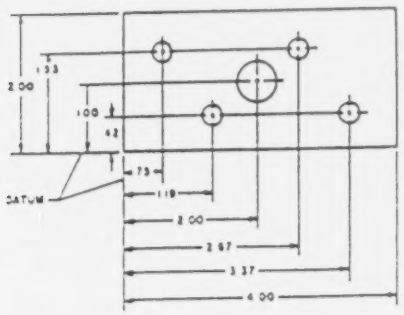
XXV. How to dimension an object using coordinate dimension systems

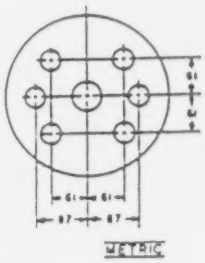
A. Rectangular coordinate system

1. All horizontal dimensions are from a common datum line

2. All vertical dimensions are from a common datum line

Examples:





NOTE: This method is used to draw parts that are to be numerically machined.

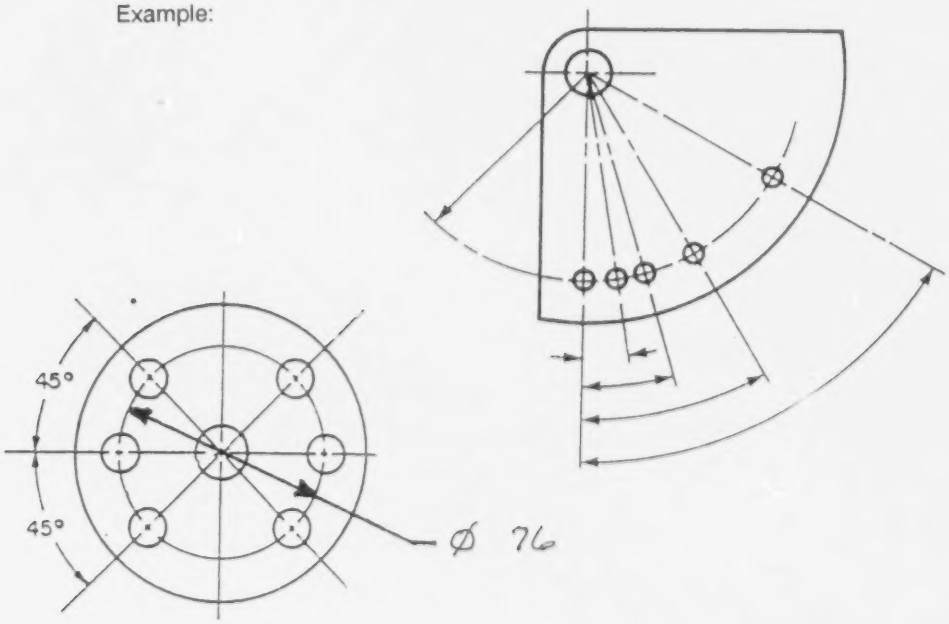
B. Polar coordinate system

NOTE: This is used when holes or other features to be located lie in a circular or radial pattern.

1. Give a radial dimension from the center of the pattern in the form of a diameter

2. Give angular dimensions from a datum

Example:

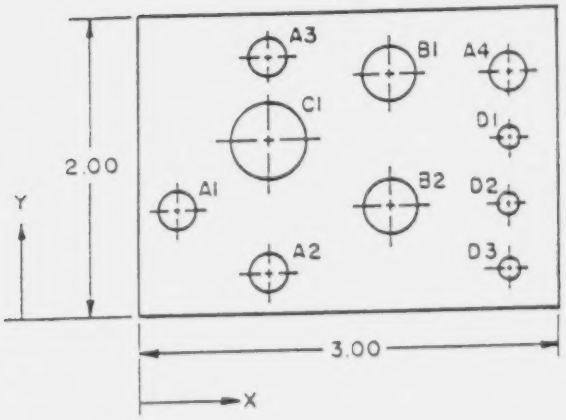


C. Tabular coordinate system

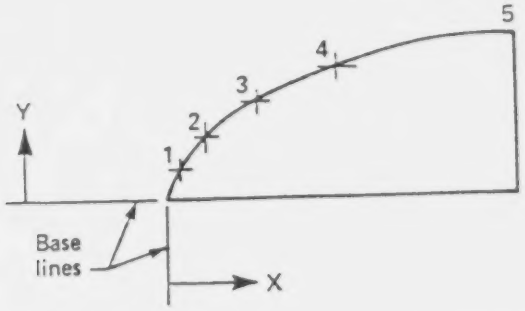
1. Dimension placement is the same as for rectangular coordinate dimensioning, using horizontal and vertical datum planes

2. Dimension figures are not applied directly to the views but are placed in a table and the holes are labeled with a code letter

Examples:



	REQ'D	4	2	1	3
	HOLE DIA.	.250	.312	.500	.125
POSITION		HOLE SYMBOL			
X —	Y ↓	A	B	C	D
.250	.625	A1			
1.000	.250	A2			
1.000	1.750	A3			
2.750	1.500	A4			
1.750	1.500		B1		
1.750	.625		B2		
1.000	1.000			C1	
2.750	1.000				D1
2.750	.625				D2
2.750	.250				D3



Station	1	2	3	4	5
X	2	5	15	27	55
Y	4.3	8.2	15	19.3	24.4

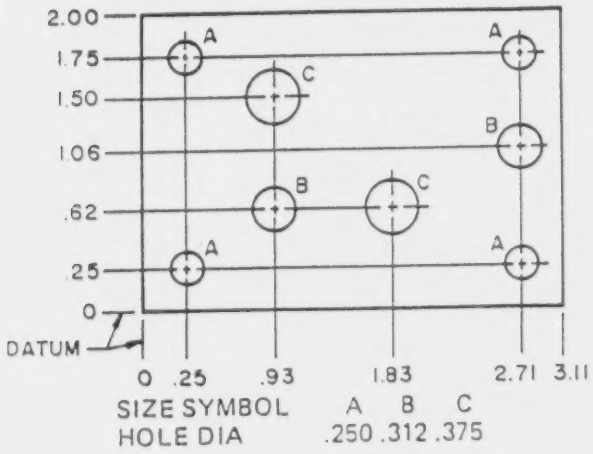
D. Ordinate dimensioning

NOTE: Other names for this system are zero plane or arrowless.

1. Dimension placement is the same as for rectangular coordinate in that it uses perpendicular datum planes

2. The datum planes are indicated as zero coordinates

3. Dimensions from these planes are shown on extension lines without the use of dimension lines or arrowheads



XXVI. How to avoid superfluous dimensions (TM 1.20, 1.21, 1.22)

A. Give dimensions in the most direct and simple way

B. Always dimension to shop operation requirements

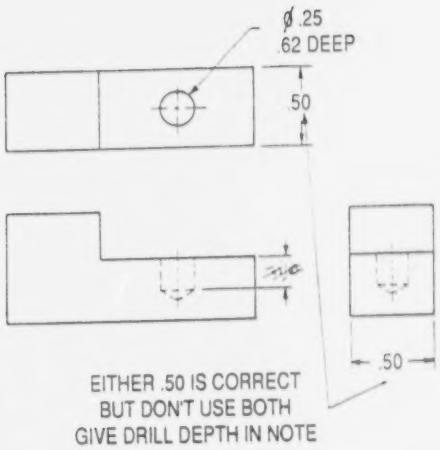
C. Never give a dimension more than once in the same view or in different views

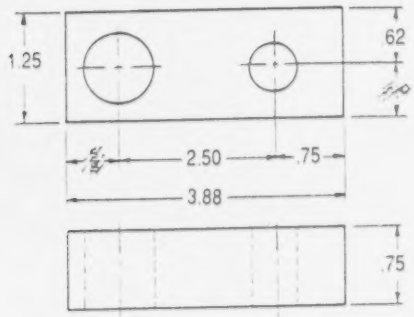
D. Remember that the worker should never have to do any calculations from a drawing to find a necessary dimension

XXVII. Reasons for avoiding superfluous dimensions

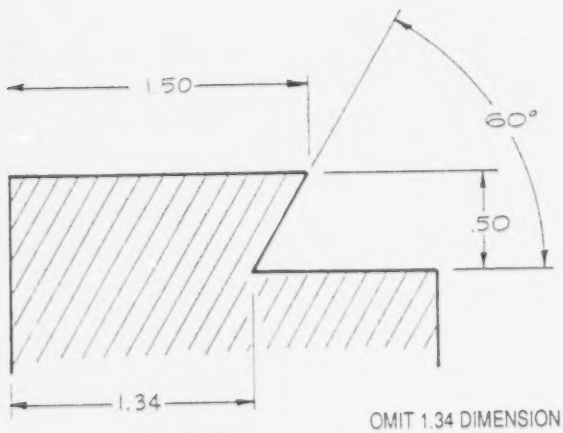
A. Duplication of effort (wasted time)

B. Increased chance of error for drafter and workers

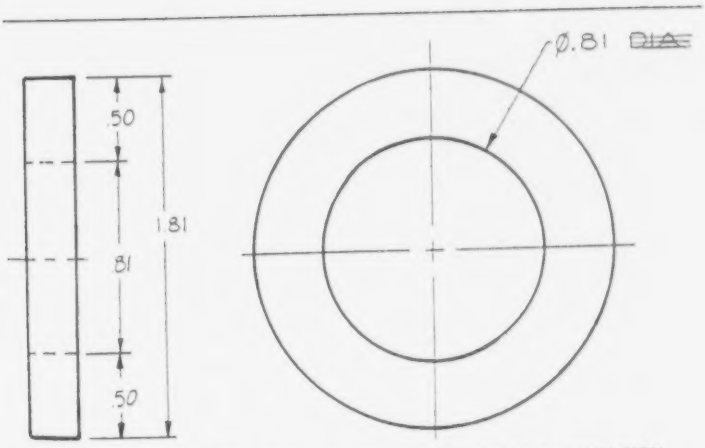




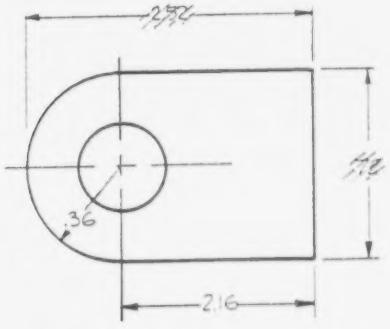
OMIT ONE DIMENSION IN A CHAIN



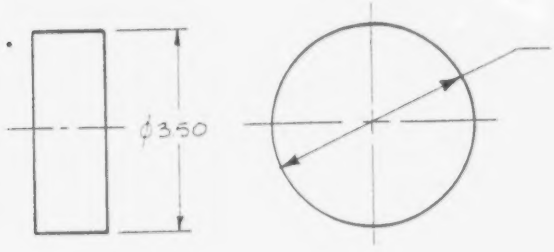
OMIT 1.34 DIMENSION



OMIT THE .50 DIMENSIONS AND THE .81 DIMENSION



Omit width and overall length



Omit diagonal diameter

XXVIII. Purpose for a notation on a drawing--to provide in concisely worded statements information that cannot be given by standard dimensions

XXIX. Rules for notations

A. Notes are always placed parallel to the bottom of the drawing

B. Notes should be brief and clear and contain only pertinent data

C. Notes should be spaced far enough from the views not to crowd, but still close enough to eliminate the need for a long leader

D. Notes should always be composed so that the various shop operations are listed in the order in which they should be performed

E. Use upper case letters for all notes on machine drawings

XXX. Two types of notes used on a drawing and their definitions

A. General note--consists of information which applies to the entire drawing

Example: All fillets and rounds R.12 unless other wise specified

B. Local (specific) note--refers to one particular feature and requires the use of a leader

Example:

XXXI. Common abbreviations and meanings

A. ANSI--American National Standards Institute

B. ASSY--assembly

C. BEV-bevel

D. BC--bolt circle

E. CL--center line

F. C to C--center to center

G. CHAM--chamfer

H. CRS--cold rolled steel

I. DEG--degree

J. DIA--diameter

K. DIM dimension

L. DWG--drawing

M. ID--inside diameter

N. MATL--material

O. MIL-STD--military standard

P. OD--outside diameter

Q. R--radius

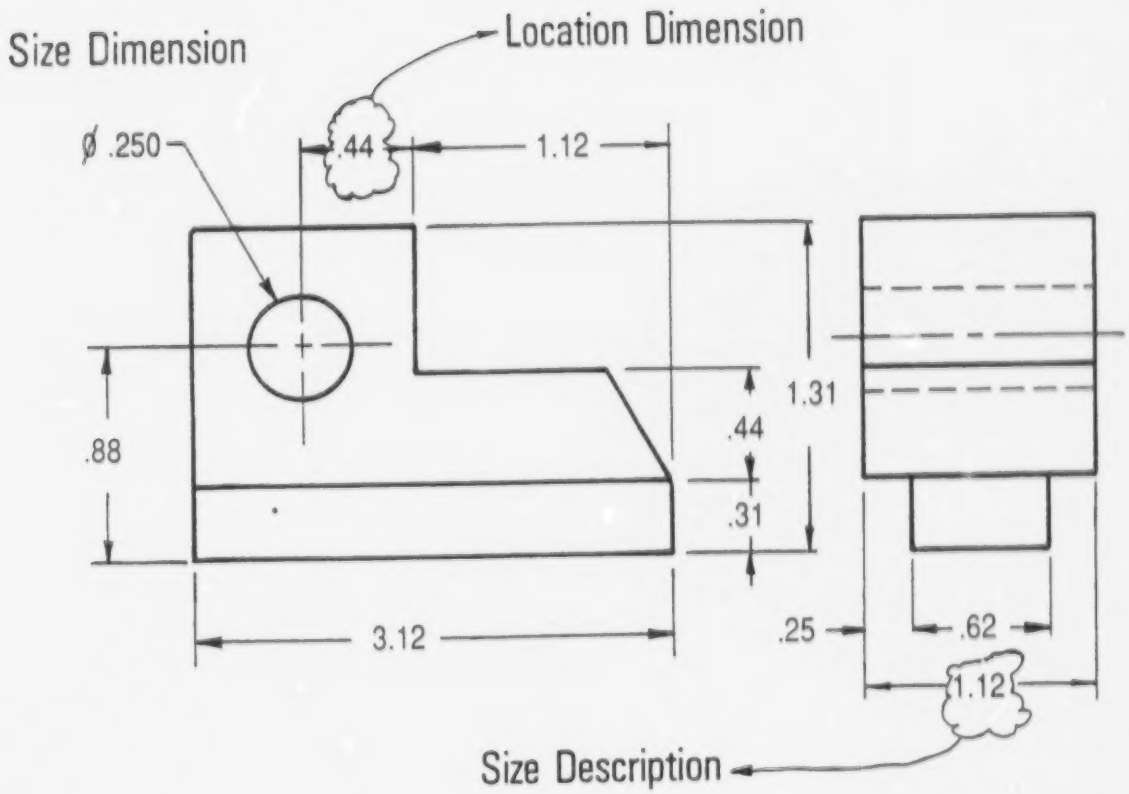
R. SAE-Society of Automotive Engineers

XXXII. Standard abbreviations

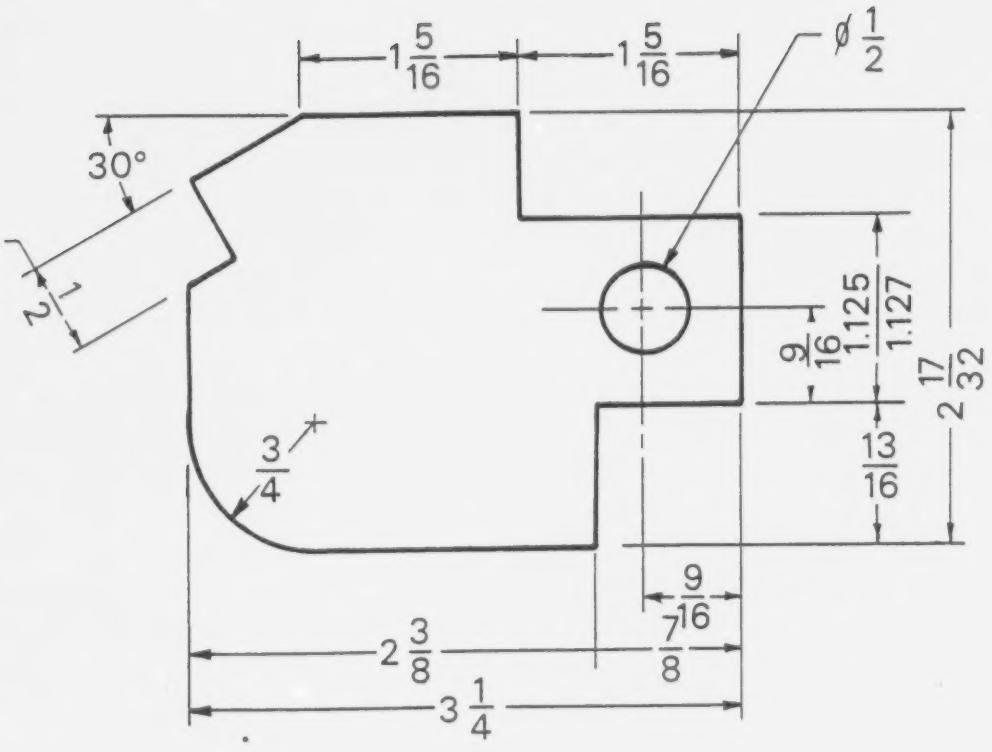
A	
Absolute	ABS
Accelerate	ACCEL
Accessory	ACCESS.
Account	ACCT
Accumulate	ACCUM
Actual	ACT.
Adapter	ADPT
Addendum	ADD.
Addition	ADD.
Adjust	ADJ
Advance	ADV
After	AFT.
Aggregate	AGGR
Air Condition	AIR COND
Airplane	APL
Allowance	ALLOW
Alloy	ALY
Alteration	ALT
Alternate	ALT
Alternating Current	AC
Altitude	ALT
Aluminum	AL
American National Standard	AMER NATL STD
American Wire Gage	AWG
Amount	AMT
Ampere	AMP
Amplifier	AMP
Anneal	ANL
Antenna	ANT.
Apartment	APT.
Apparatus	APP
Appendix	APPX
Approved	APPD
Approximate	APPROX
Arc Weld	ARC/W
Area	A
Armature	ARM.
Armor Plate	ARM-PL
Army Navy	AN
Arrange	ARR.
Artificial	ART.
Asbestos	ASB
Asphalt	ASPH
Assemble	ASSEM
Assembly	ASSY
Assistant	ASST
Associate	ASSOC
Association	ASSN
Atomic	AT
Audible	AUD
Audio Frequency	AF
Authorized	AUTH
Automatic	AUTO
Auto-Transformer	AUTO TR
Auxiliary	AUX
Avenue	AVE
Average	AVG
Aviation	AVI
Azimuth	AZ
B	
Babbitt	BAB
Back Feed	BF
Back Pressure	BP
Back to Back	B to B
Backface	BF
Balance	BAL
Ball Bearing	BB
Barometer	BAR
Base Line	BL
Base Plate	BP
Bearing	BBRG
Bench Mark	BM
Bending Moment	M
Bent	BT
Bessemer	BESS
Between	BET.
Between Centers	BC
Between Perendiculars	BP
Bevel	BEV
Bill of Material	B/M
Birmingham Wire Gage	BWG
Blank	BLK
Block	BLK
Blueprint	BP
Board	BD
Boiler	BLR
Boiler Feed	BF
Boiler Horsepower	BHP
Boiling Point	BP
Bolt Circle	BC
Both Faces	BF
Both Sides	BS
Both Ways	BW
Bottom	BOT
Bottom Chord	BC
Bottom Face	BF
Bracket	BRKT
Brake	BK
Brake Horsepower	BHP
Brass	BRS
Brazing	BRZG
Break	BRK
Brinell Hardness	BH
British Standard	BR STD
British Thermal Units	BTU
Broach	BRO
Bronze	BRZ
Brown & Sharpe (Wire Gage, same as AWG)	B & S
Building	BLDG
Bulkhead	BHD
Burnish	BNH
Bushing	BUSH.
Button	BUT.
C	
Cabinet	CAB.
Calculate	CALC
Calibrate	CAL
Cap Screw	CAP SCR
Capacity	CAP
Carburetor	CARB
Carburize	CARB
Carriage	CRG
Case Harden	CH
Cast Iron	CI
Cast Steel	CS
Casting	CSTG
Castle Nut	CAS NUT
Catalogue	CAT.
Cement	CEM
Center	CTR
Center Line	CL
Center of Gravity	CG
Center of Pressure	CP
Center to Center	C to C
Centering	CTR
Chamfer	CHAM
Change	CHG
Channel	CHAN
Check	CHK
Check Valve	CV
Chord	CHD
Circle	CIR
Circular	CIR
Circular Pitch	CP
Circumference	CIRC
Clear	CLR
Clearance	CL
Clockwise	CW
Coated	CTD
Cold Drawn	CD
Cold Drawn Steel	CDS
Cold Finish	CF
Cold Punched	CP
Cold Rolled	CR
Cold Rolled Steel	CRS
Combination	COMB.
Combustion	COMB
Commercial	COML
Company	CO
Complete	COMPL
Compress	COMP
Compress	COMP
Concentric	CONC
Concrete	CONC
Condition	COND
Connect	CONN
Constant	CONST
Construction	CONST
Contact	CONT
Continue	CONT
Copper	COP.
Corner	COR
Corporation	CORP
Correct	CORR
Corrugate	CORR
Cotter	COT
Counter	CTR
Counter Clockwise	CCW
Counterbore	CBORE
Counterdrill	CDRILL
Counterpunch	CPUNCH
Countersink	CSK
Coupling	CPLG
Cover	COV
Cross Section	XSECT
Cubic	CU
Cubic Foot	CU FT
Cubic Inch	CU IN.
Current	CUR
Customer	CUST
Cyanide	CYN
D	
Decimal	DEC
Dedendum	DED
Deflect	DEFL
Degree	( ) DEG
Density	D
Department	DEPT
Design	DSGN
Detail	DET
Develop	DEV
Diagonal	DIAG
Diagram	DIAG
Diameter	DIA
Diametral Pitch	DP
Dimension	DIM.
Discharge	DISCH
Distance	DIST
Division	DIV
Double	DBL
Dovetail	DVTL
Dowel	DWL
Down	DN
Dozen	DOZ
Drafting	DFTG
Draftsman	DFTSM
Drawing	DWG
Drill or Drill Rod	DR
Drive	DR
Drive Fit	DF
Drop	D
Drop Forge	DF
Drop	D
Drop Forge	DF
Duplicate	DUP
E	
Each	EA
East	E
Eccentric	ECC
Effective	EFF
Elbow	ELL
Electric	ELEC
Elementary	ELEM
Elevate	ELEV
Elevation	EL
Engine	ENG
Engineer	ENGR
Engineering	ENGRG
Entrance	ENT
Equal	EQ
Equation	EQ
Equipment	EQUIP
Equivalent	EQUIV
Estimate	EST
Exchange	EXCH
Exhaust	EXH
Existing	EXIST.
Exterior	EXT
Extra Heavy	X HVY
Extra Strong	X STR
Extrude	EXTR
F	
Fabricate	FAB
Face to Face	F to F
Fahrenheit	F
Far Side	FS
Federal	FED.
Feed	FD
Feet	(') FT
Figure	FIG.
Fillet	FIL
Fillister	FIL
Finish	FIN.
Finish All Over	FAO
Flange	FLG
Flat	F
Flat Head	FH
Floor	FL
Fluid	FL
Focus	FOC
Foot	(') FT
Force	F
Forged Steel	FST
Forging	FORG
Forward	FWD
Foundry	FDRY
Frequency	FREQ
Front	FR
Furnish	FURN
G	
Gage or Gauge	GA
Gallon	GAL
Galvanize	GALV
Galvanized Iron	GI
Galvanized Steel	GS
Gasket	GSKT
General	GEN

Glass	GL
Government	GOVT
Governor	GOV
Grade	GR
Graduation	GRAD
Graphite	GPH
Grind	GRD
Groove	GRV
Ground	GRD
H	
Half-Round	1/2 RD
Handle	HDL
Hanger	HGR
Hard	H
Hardent	HDN
Hardware	HDW
Head	HD
Headless	HDLS
Heat	HT
Heat Treat	HT TR
Heavy	HVY
Hexagon	HEX
High-Pressure	HP
High-Speed	HS
Horizontal	HOR
Horsepower	HP
Hot Rolled	HR
Hot Rolled Steel	HRS
Hour	HR
Housing	HSG
Hydraulic	HYD
I	
Illustrate	ILLUS
Inboard	INBBD
Inch	(") IN.
Inches per Second	IPS
Inclosure	INCL
Include	INCL
Inside Diameter	ID
Instrument	INST
Interior	INT
Internal	INT
Intersect	INT
Iron	I
Irregular	IRR
J	
Joint	JT
Joint Army-Navy	JAN
Journal	JNL
Junction	JCT
K	
Key	K
Keyseat	KST
Keyway	KWY
L	
Laboratory	LAB
Laminate	LAM
Lateral	LAT
Left	L
Left Hand	LH
Length	LG
Length Over All	LOA
Letter	LTR
Light	LT
Line	L
Locate	LOC
Logarithm	LOG.
Long	LG
Lubricate	LUB
Lumber	LBR
M	
Machine	MACH
Machine Steel	MS
Maintenance	MAINT
Malleable	MALL
Malleable Iron	MI
Manual	MAN.
Manufacture	MFR
Manufactured	MRD
Manufacturing	MFG
Material	MATL
Maximum	MAX
Mechanical	MECH
Mechanism	MECH
Median	MED
Metal	MET.
Meter	M
Miles	MI
Miles per Hour	MPH
Millimeter	MM
Minimum	MIN
Minute	(') MIN
Miscellaneous	MISC
Month	MO
Morse Taper	MOR T
Motor	MOT
Mounted	MTD
Mounting	MTG
Multiple	MULT
Music Wire Gage	MWG
N	
National	NATL
Natural	NAT
Near Face	NF
Near Side	NS
Negative	NEG
Neutral	NEUT
Nominal	MON
Normal	NOR
North	N
Not to Scale	NTS
Number	NO.
O	
Obsolete	OBS
Octagon	OCT
Office	OFF.
On Center	OC
Opposite	OPP
Optical	PPT
Original	ORIG
Outlet	OUT.
Outside Diameter	OD
Outside Face	OF
Outside Radius	OR
Overall	OA
P	
Pack	PK
Packing	PKG
Page	P
Paragraph	PAR.
Part	PT
Patent	PAT.
Pattern	PATT
Permanent	PERM
Perpendicular	PERP
Piece	PC
Piece Mark	PC MK
Pint	PT
Pitch	P
Pitch Circle	PC
Pitch Diameter	PD
Plastic	PLSTC
Plate	PL
Plumbing	PLMB
Point	PT
Point of Curve	PX
Point of Intersection	PI
Point of Tangent	PT
Polish	POL
Position	POS
Potential	POT.
Pound	LB
Pounds per Square Inch	PSI
Power	PWR
Prefabricated	PREFAB
Preferred	PFDS
Prepare	PREP
Pressure	PRESS.
Process	PROC
Production	PROD
Profile	PF
Propeller	PROP
Publication	PUB
Push Button	PB
Q	
Quadrant	QUAD
Quality	QUAL
Quarter	QTR
R	
Radial	RAD
Radius	R
Railroad	RR
Ream	RM
Received	RECD
Record	REC
Rectangle	RECT
Reduce	RED.
Reference Line	REF L
Reinforce	REINF
Release	REL
Relief	REL
Remove	REM
Require	REQ
Required	REQD
Return	RET.
Reverse	REV
Revolution	REV
Revolutions per Minute	RPM
Right	R
Right Hand	RH
Rivet	RIV
Rockwell Hardness	RH
Roller Bearing	RB
Room	RM
Root Diameter	RD
Root Mean Square	RMS
Rough	RGH
Round	RD
S	
Schedule	SCH
Schematic	SCHEM
Scleroscope Hardness	SH
Screw	SCR
Second	SEC
Section	SECT
Semi-Steel	SS
Separate	SEP
Set Screw	SS
Shaft	SFT
Sheet	SH
Shoulder	SHLD
Side	S
Single	S
Sketch	SK
Sleeve	SLV
Slide	SL
Slotted	SLOT.
Small	SM
Socket	SOC
Space	SP
Speical	SPL
Specific	SP
Spot Faced	SF
Spring	SPG
Square	SQ
Standard	STD
Station	STA
Stationary	STA
Steel	STL
Stock	STK
Straight	STR
Street	ST
Structural	STR
Substitute	SUB
Summary	SUM.
Support	SUP.
Surface	SUR
Symbol	SYM
System	SYS
T	
Tangent	TAN.
Taper	TPR
Technical	TECH
Template	TEMP
Tension	TENS.
Terminal	TERM.
Thick	THK
Thousand	M
Thread	THD
Threads per Inch	TPI
Through	THRU
Time	T
Tolerance	TOL
Tongue & Groove	T & G
Tool Steel	TS
Tooth	T
Total	TOT
Transfer	TRANS
Typical	TYP
U	
Ultimate	ULT
Unit	U
Universal	UNIV
V	
Vacuum	VAC
Valve	V
Variable	VAR
Versus	VS
Vertical	VERT
Volt	V
Volume	VOL
W	
Wall	W
Washer	WASH.
Watt	W
Week	WK
Weight	WT
West	W
Width	W
Wood	WD
Woodruff	WDF
Working Point	WP
Working Pressure	WP
Wrought	WRT
Wrought Iron	WI
X, Y, Z	
Yard	YD
Year	YR

Descriptions and Dimensions



Aligned System

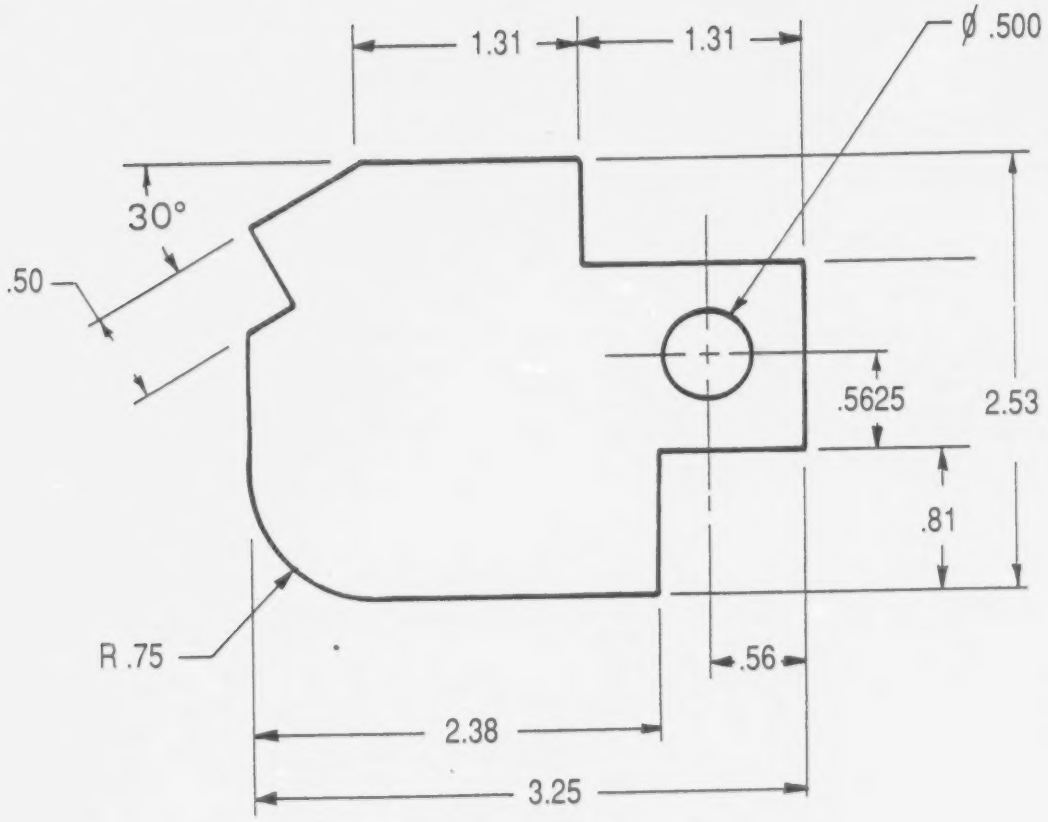


USED ON:

- **ARCHITECTURAL DRAWINGS**
- **WOOD CABINET OR FURNITURE DRAWINGS**
- **STRUCTURAL DRAWINGS**

Unidirectional System

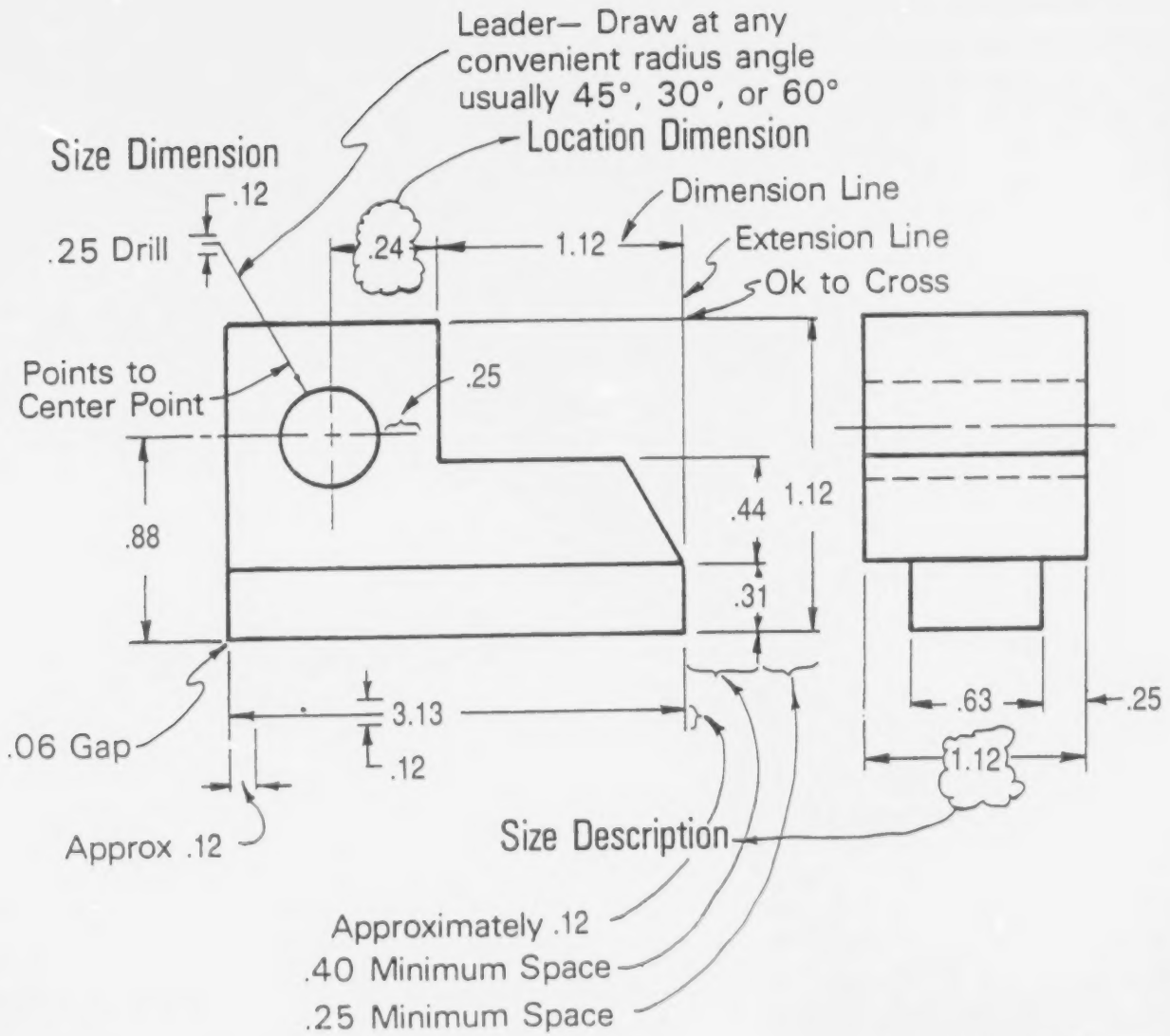
RECOGNIZED STANDARD FOR ENGINEERING DRAWINGS PER ANSI Y14.5M - 1982



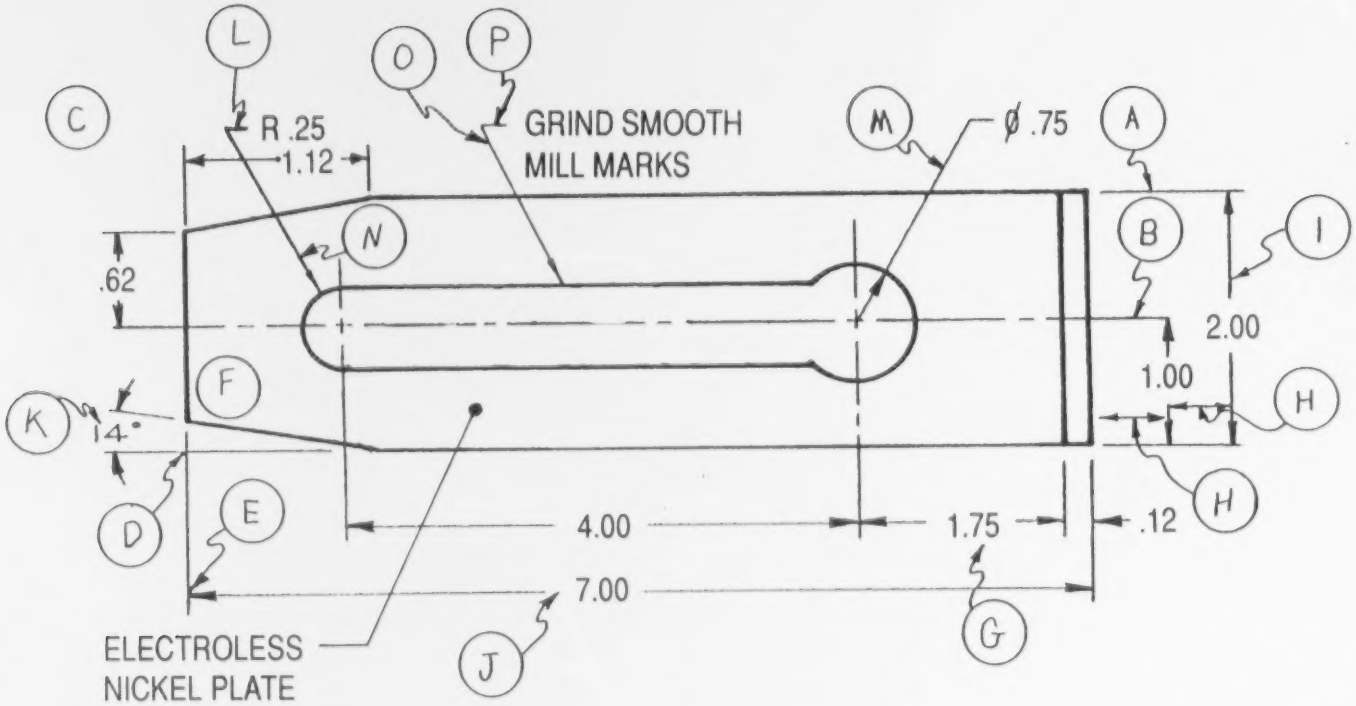
USED ON:

- PRODUCTION MACHINE DRAWINGS
- PRODUCTION ELECTRICAL/ELECTRONIC DRAWINGS

Types of Lines

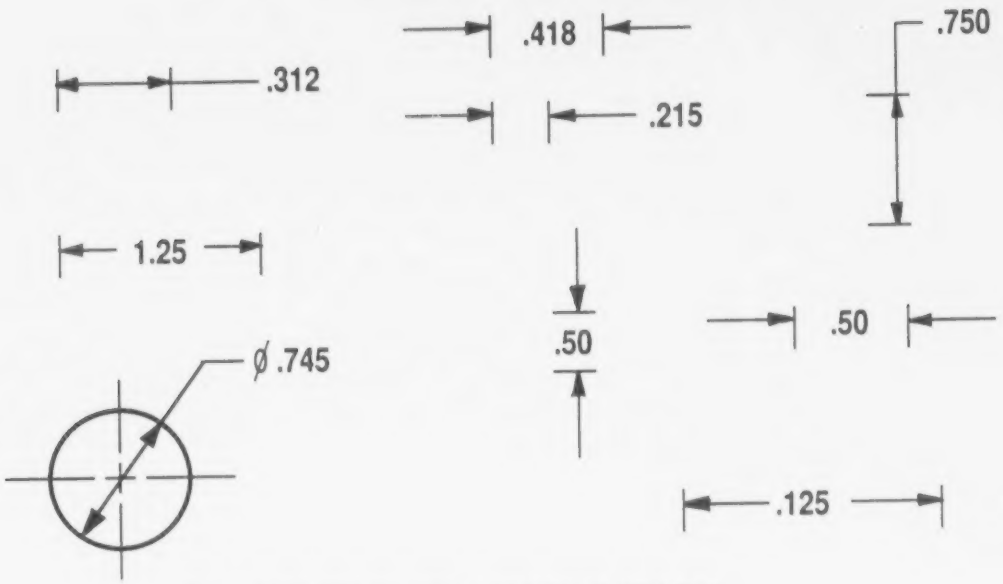


Rules for Lines

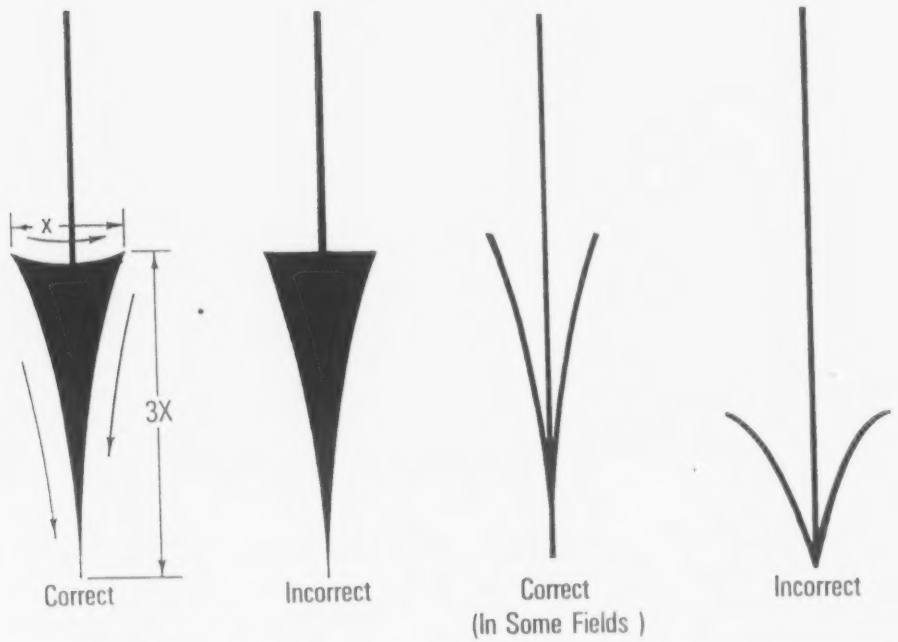


TM 1.6

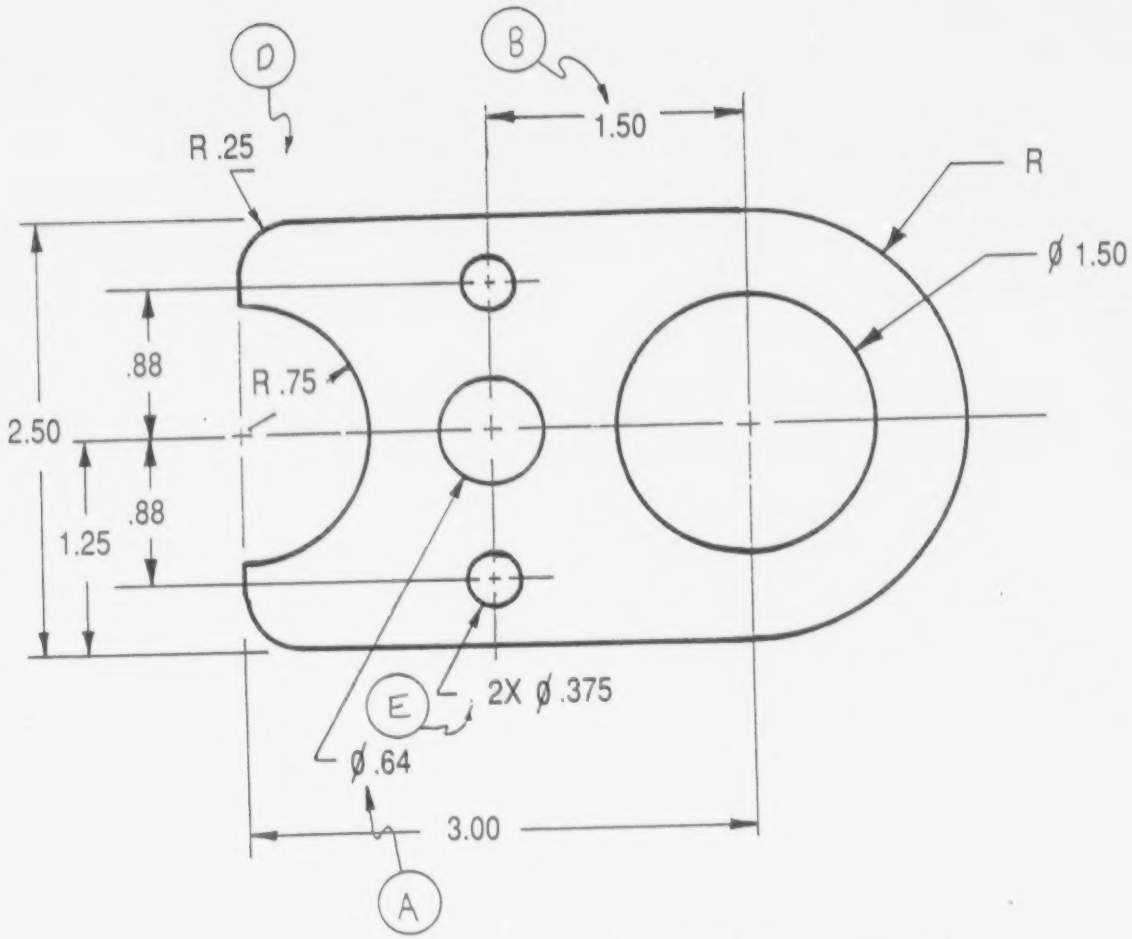
Arrowheads

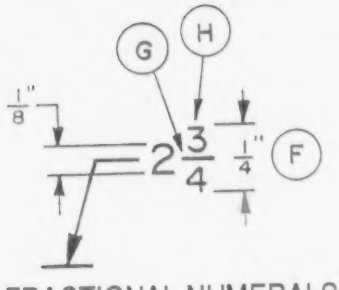


PLACEMENT OF ARROWHEADS

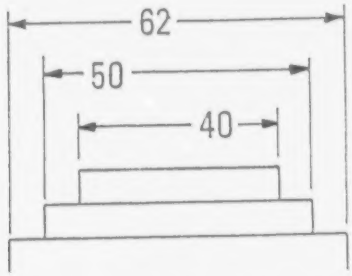


Rules For Figures



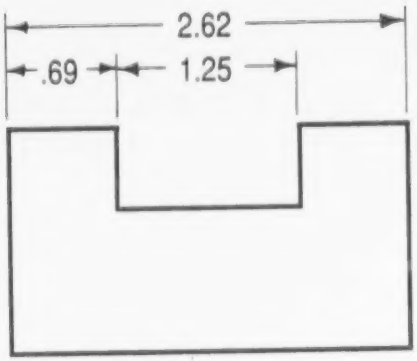


FRACTIONAL NUMERALS

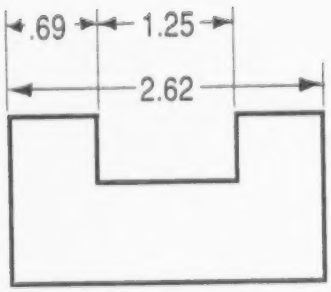


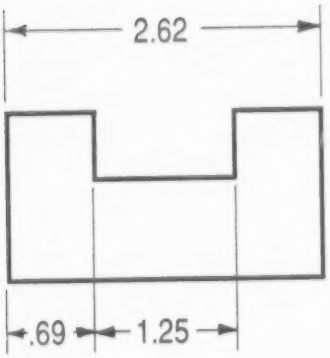
(I) STAGGERED NUMERALS

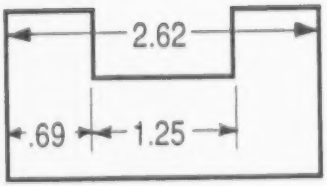
Placement of Dimensions

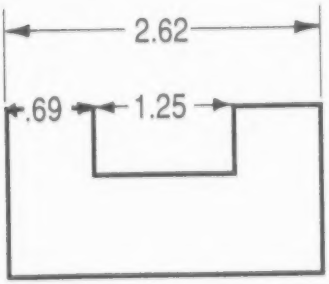


CORRECT



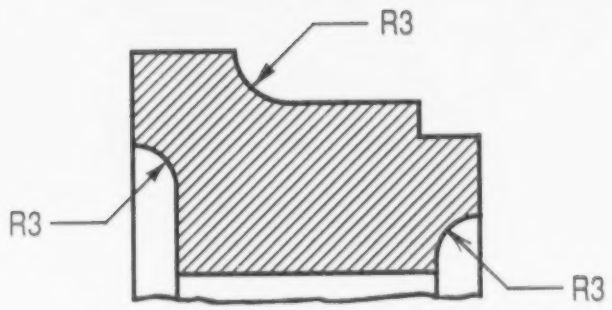




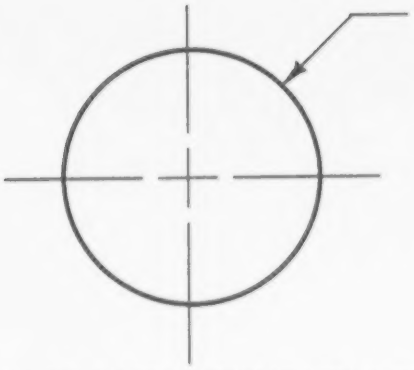


INCORRECT

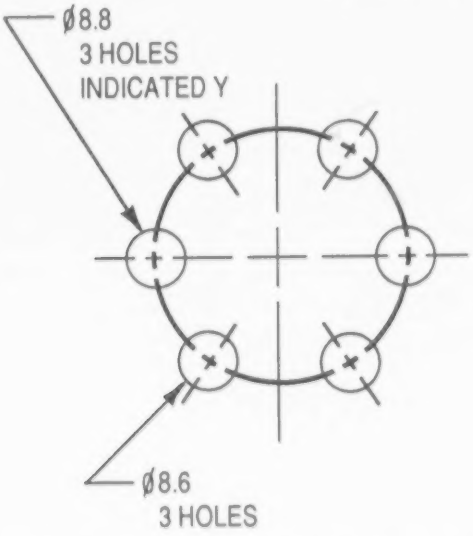
Placement of Leaders



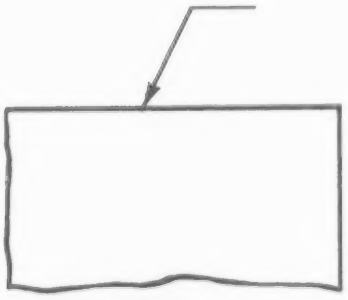
ONE LEADER FOR EACH FEATURE



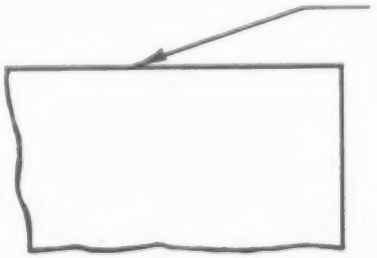
LEADER DIMENSIONING HOLE SIZE



WHERE MANY LEADERS WOULD BE CONFUSING

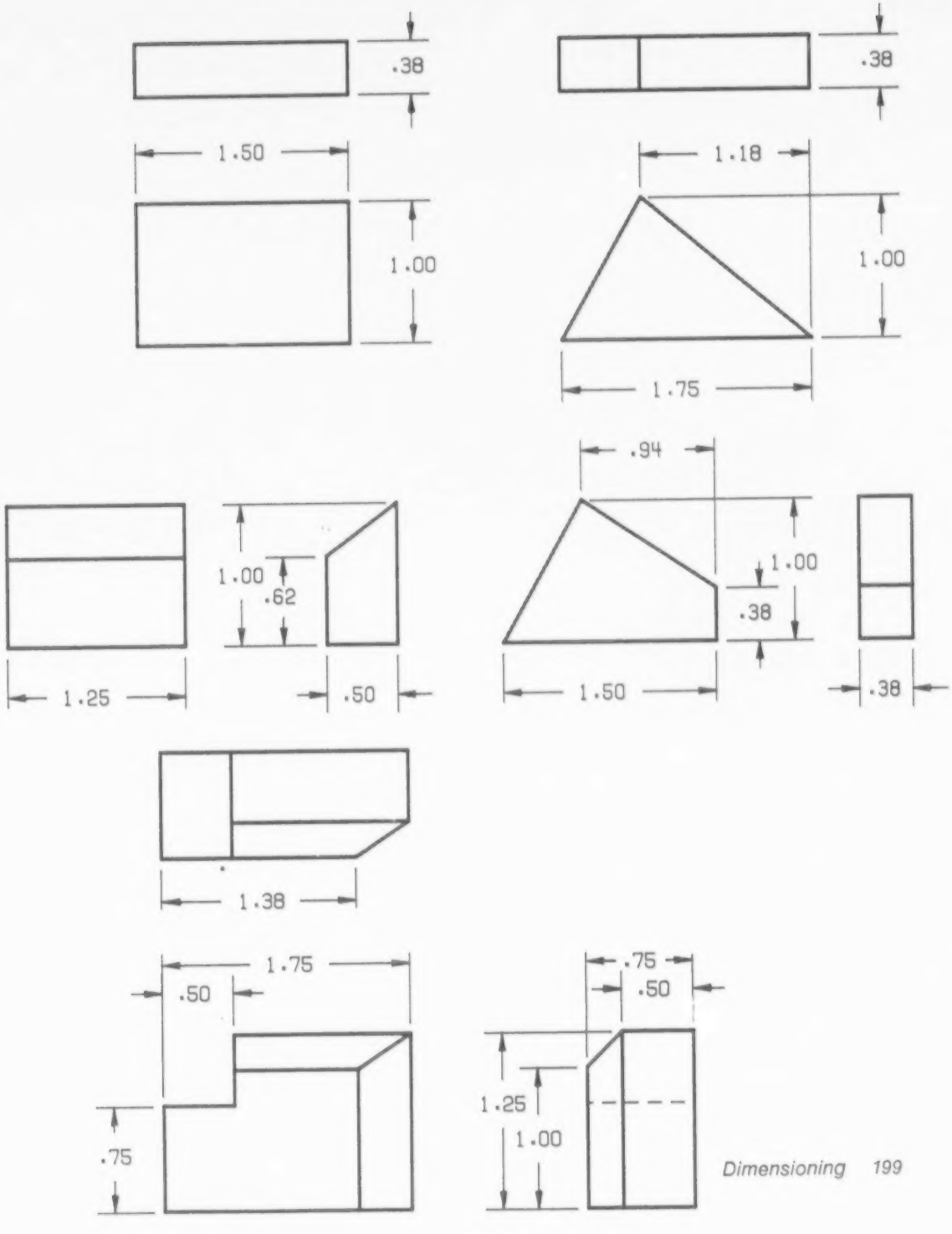


CORRECT

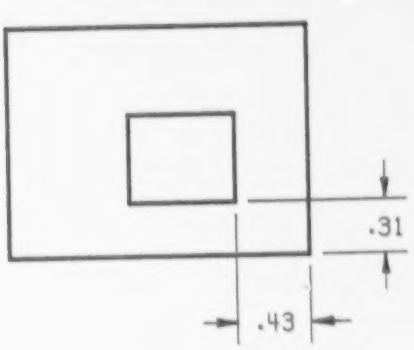


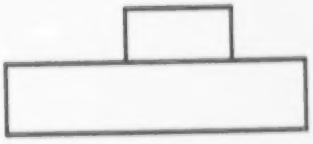
INCORRECT

Dimensioning Prisms

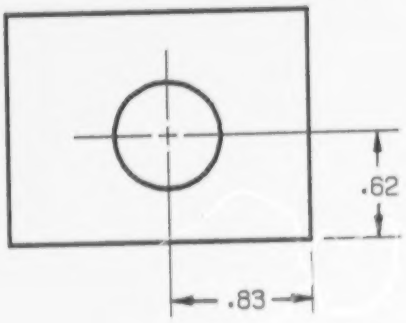


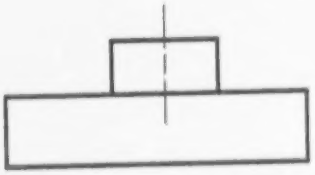
Dimensioning Feature Locations



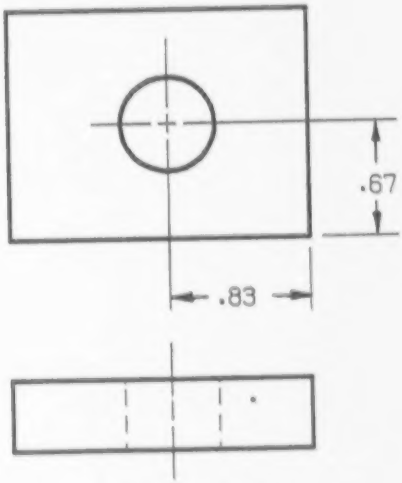


LOCATING PRISMS

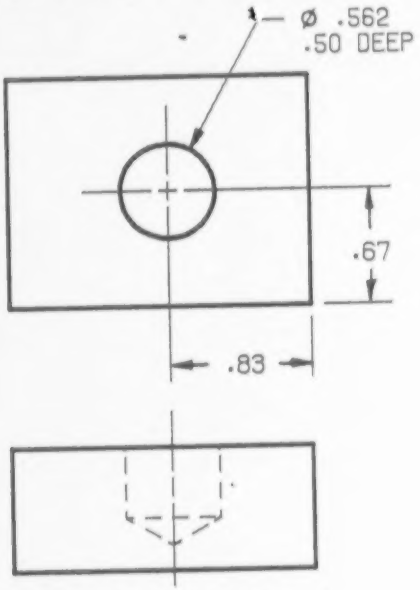




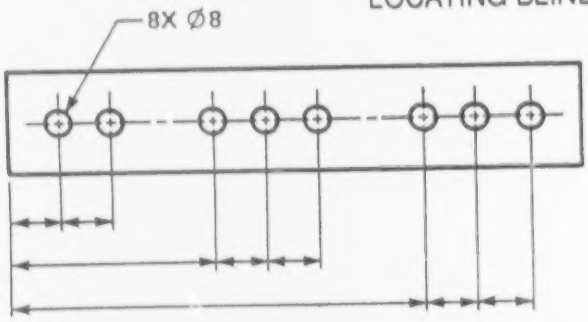
LOCATING CYLINDERS



LOCATING HOLES

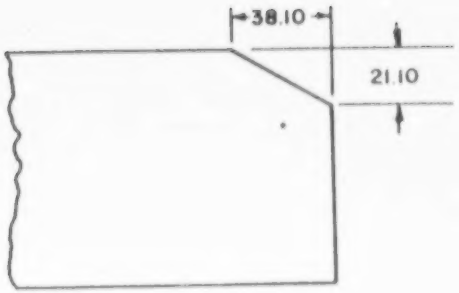


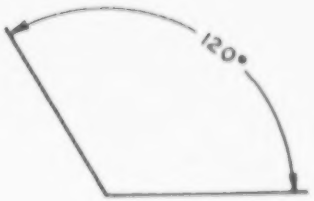
LOCATING BLIND HOLES

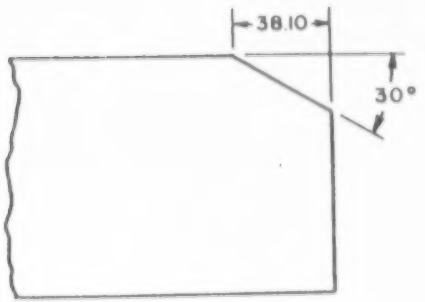


LOCATION OF REPETITIVE FEATURES

Dimensioning Angles





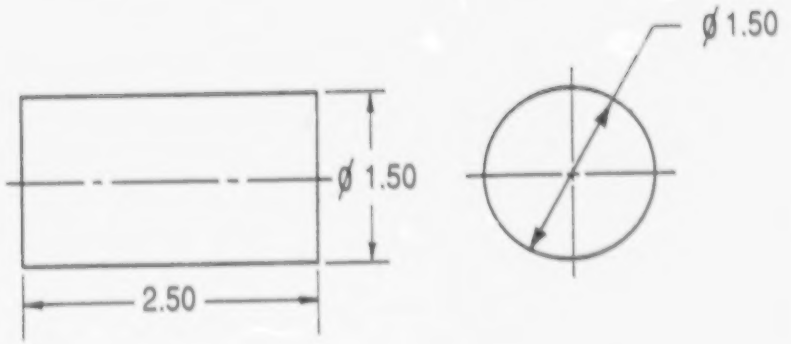


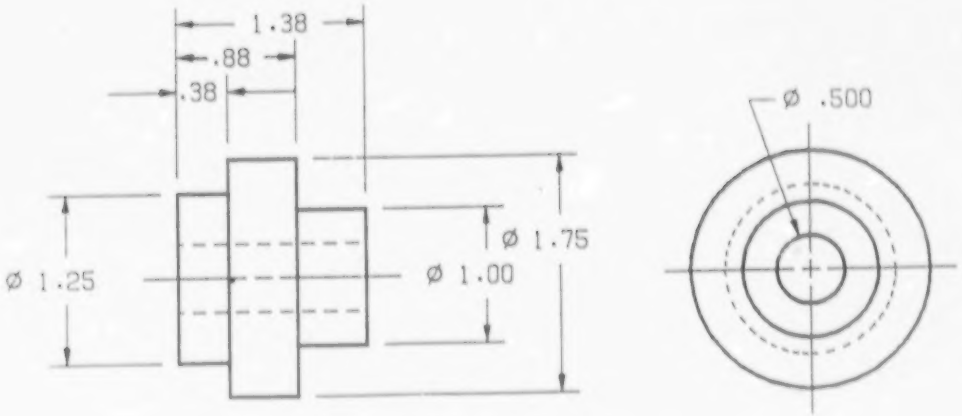
Angles May be Measures in
Degrees °
Minutes '
Seconds "

TM 1.11

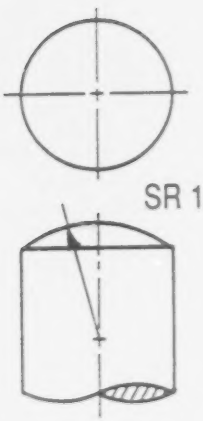
Dimensioning 203

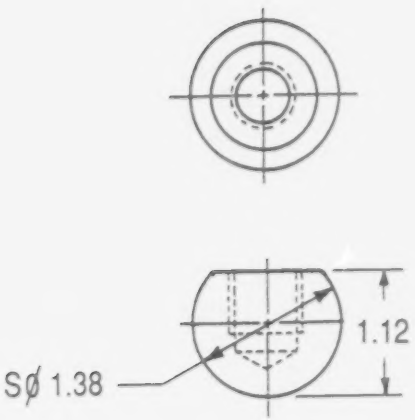
Dimensioning Cylindrical Objects



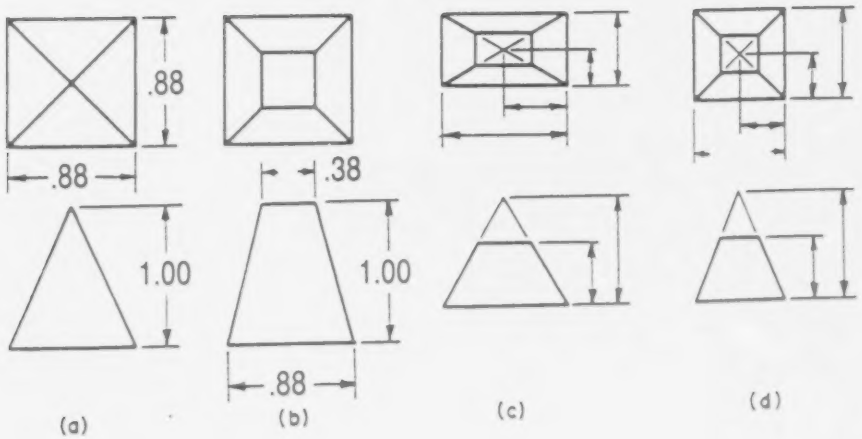


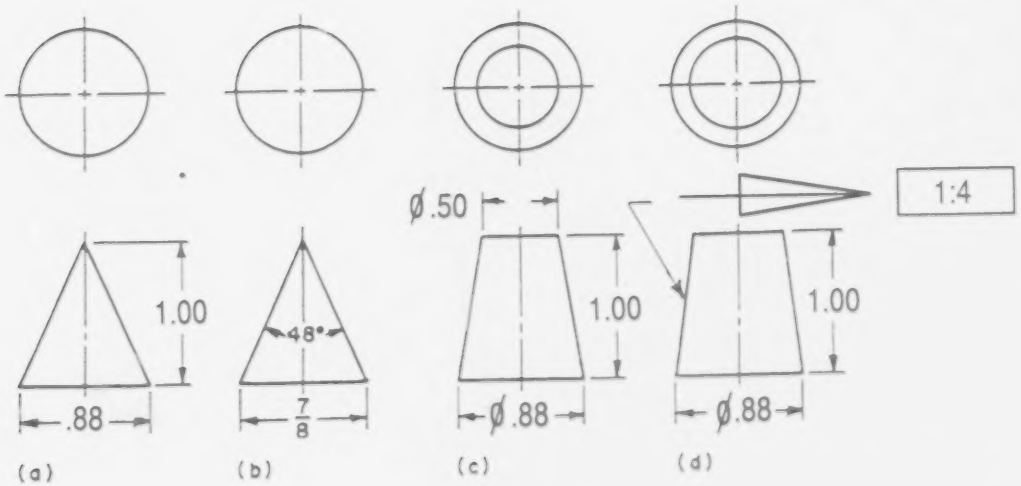
Dimensioning Spherical Objects



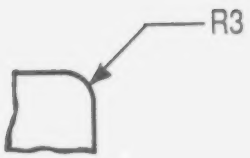


Dimensioning Pyramids & Cones

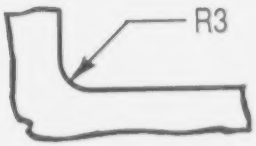




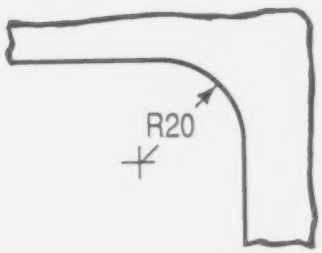
Dimensioning Arcs



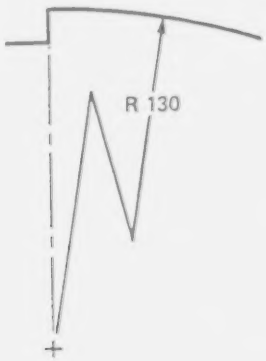
EXTERNAL ROUND



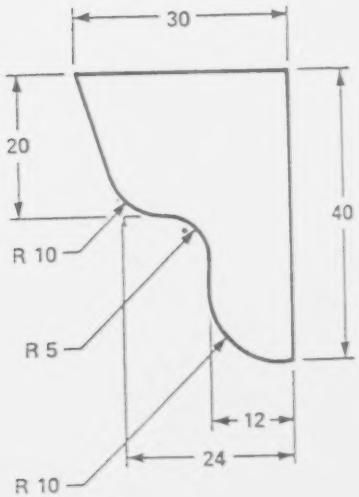
FILLET (SMALL)



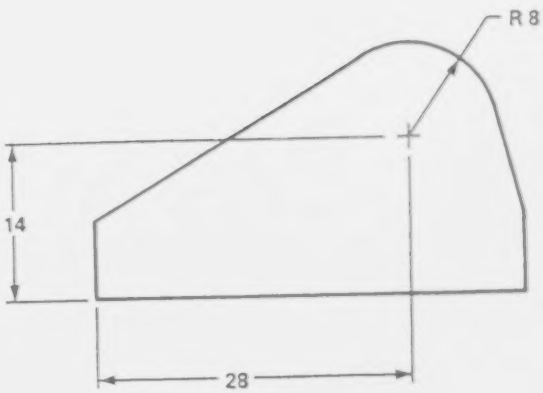
FILLET (LARGE)



CENTER LOCATED
OUTSIDE DRAWING



LOCATED BY TANGENT
LINES

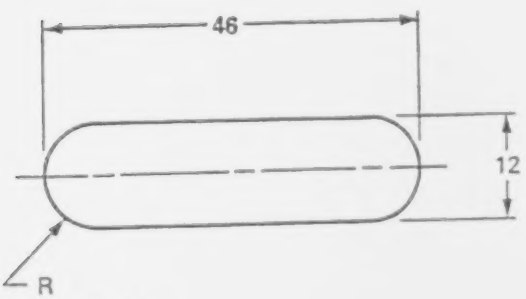


LOCATED BY
COORDINATE DIMENSIONS

METRIC

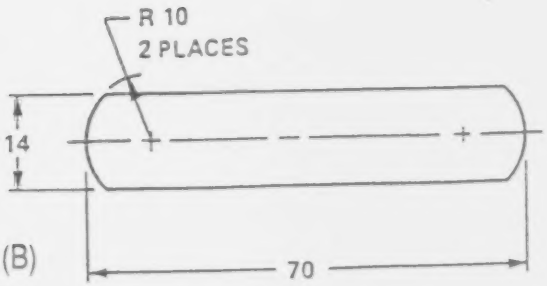
Dimensioning Rounded End Shapes

EXTERNALLY ROUNDED OBJECTS



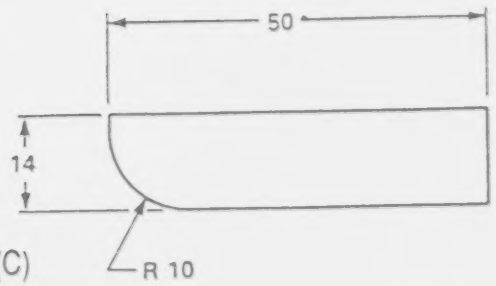
(A)

FULLY ROUNDED



(B)

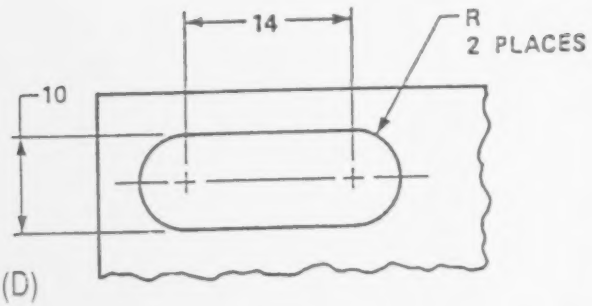
PARTIALLY ROUNDED



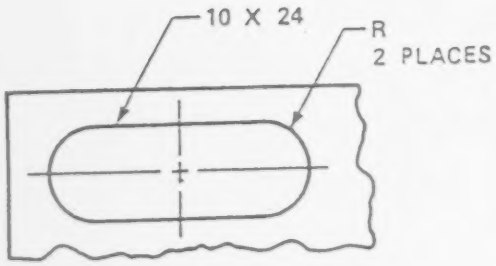
(C)

ROUNDED CORNER

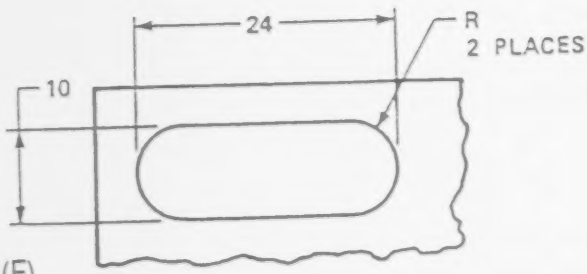
SLOTTED HOLES



(D)



(E)



(F)

METRIC

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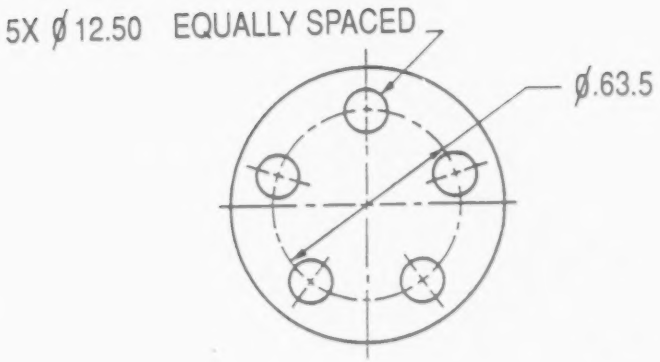
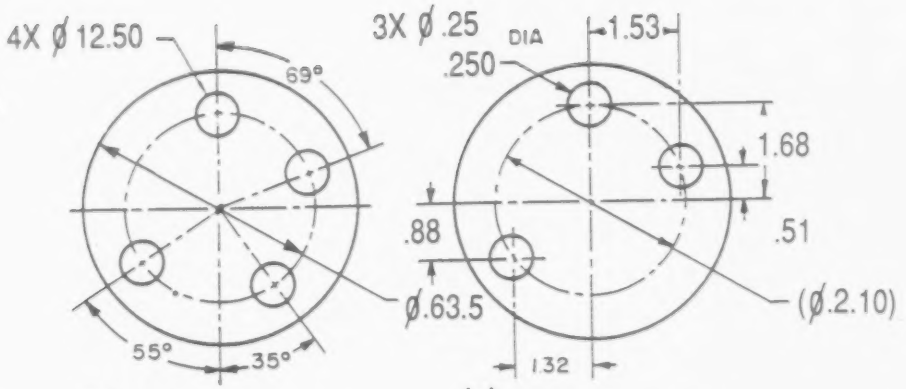
Dimension Features on a Circular Center Line



(a)

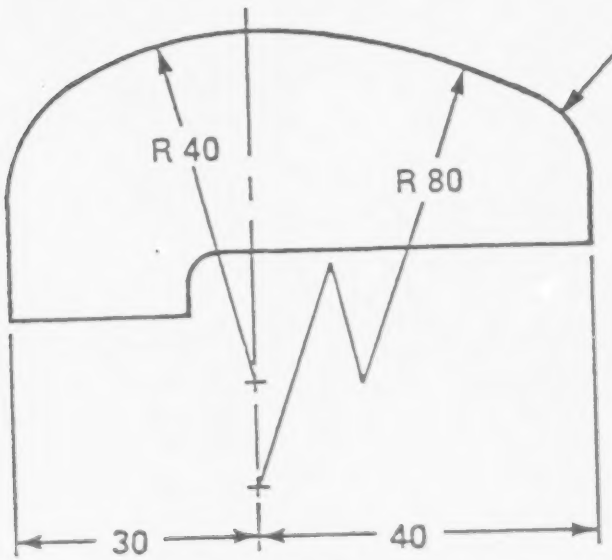


(b) POLAR COORDINATES

(c) RECTANGULAR COORDINATES

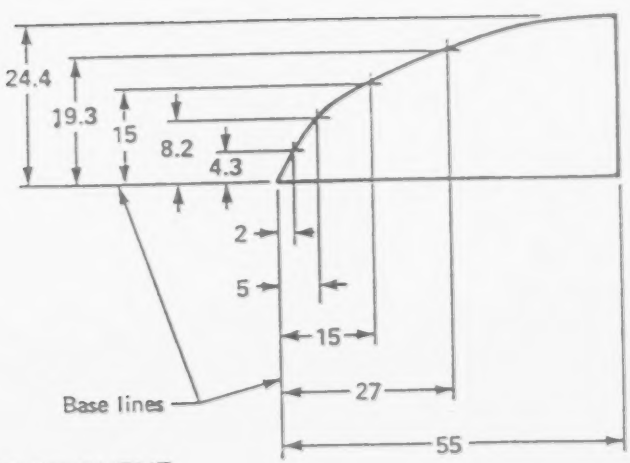
METRIC

Dimensioning Curves



METRIC

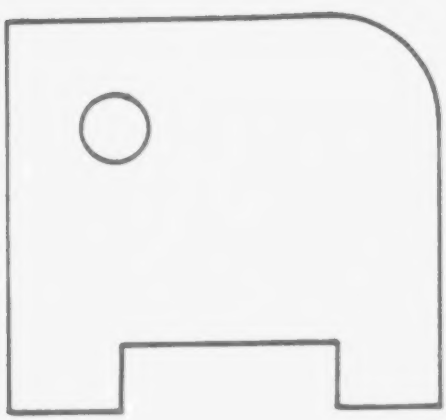
CURVES MADE FROM ARCS



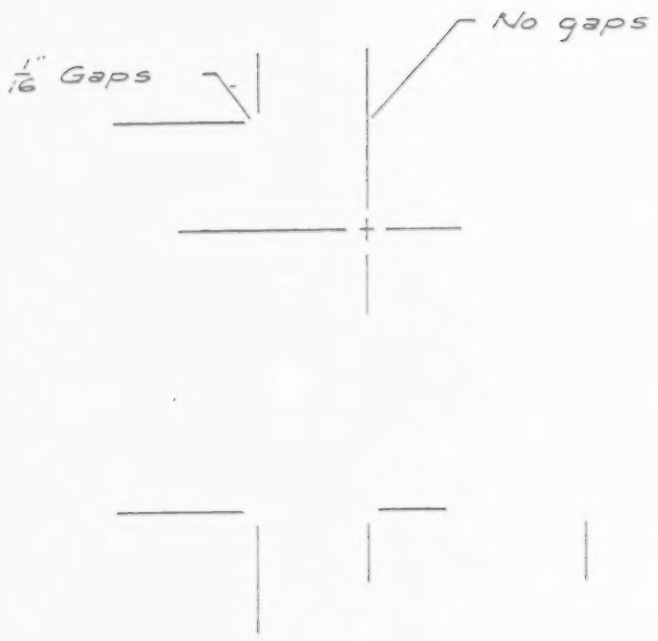
METRIC

IRREGULAR CURVE

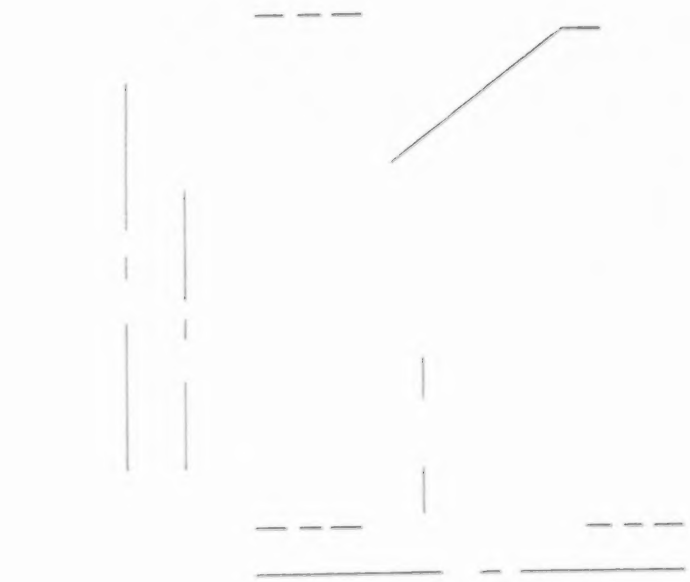
Steps in Applying Dimensions



- Views of object completed



- Add extension and center lines



- Add dimension lines and leader lines

.38

Ø.312

1.50

1.06

.25

.44

.44

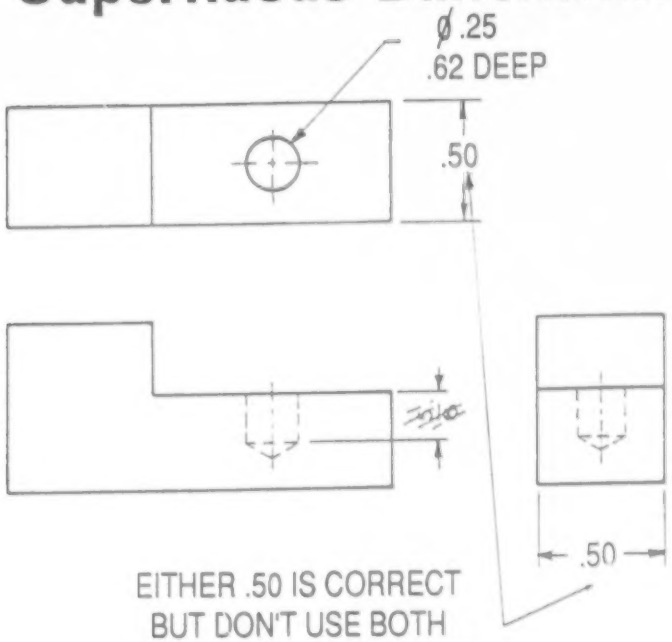
1.75

Letter in dimensions

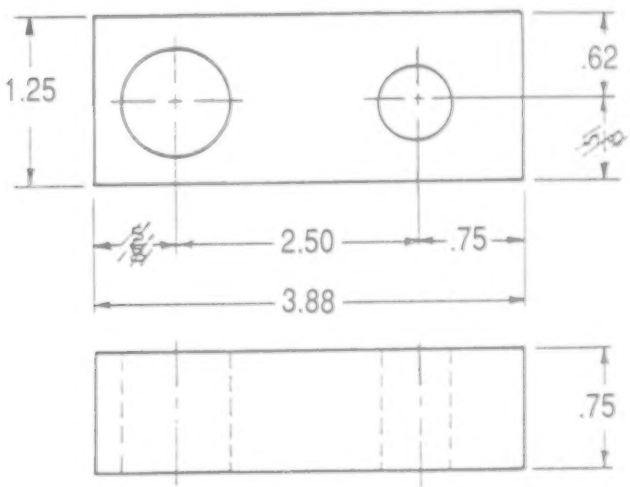
- Add arrowheads

TM 1.20

Superfluous Dimensions

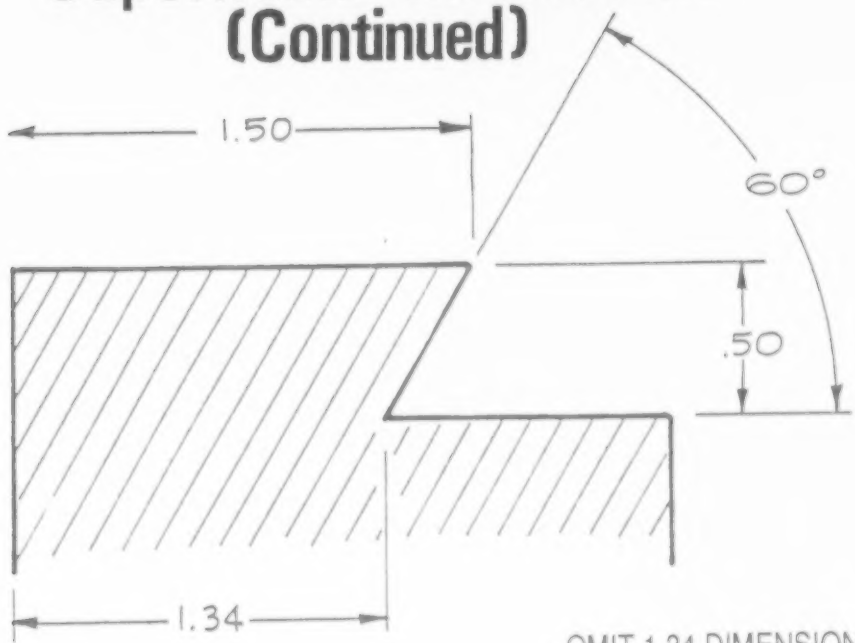


EITHER .50 IS CORRECT
BUT DON'T USE BOTH
GIVE DRILL DEPTH IN NOTE

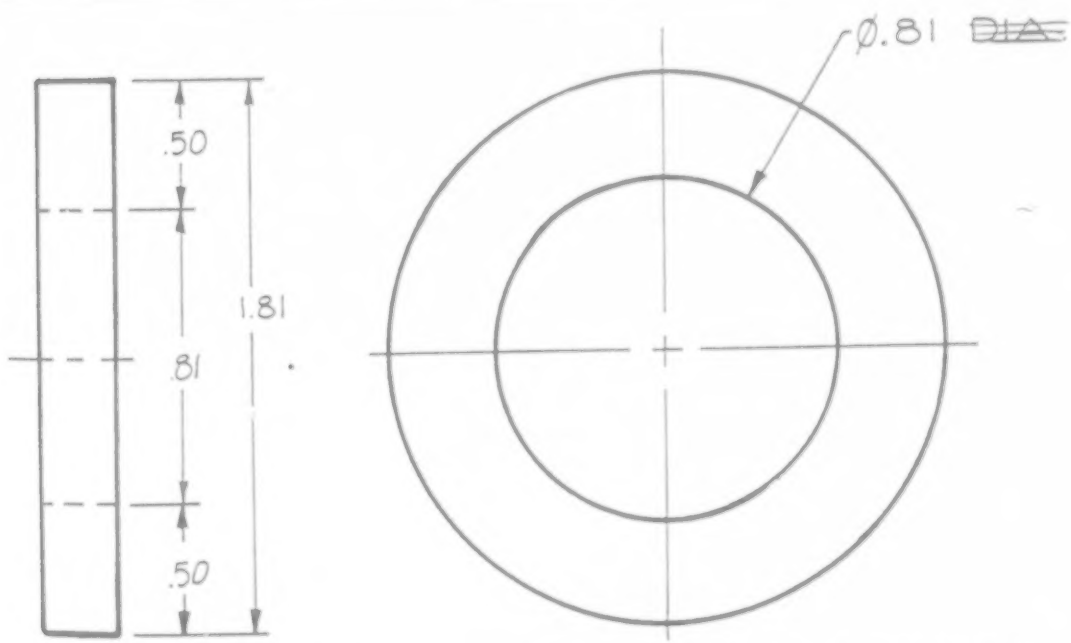


OMIT ONE DIMENSION IN A CHAIN

Superfluous Dimensions (Continued)

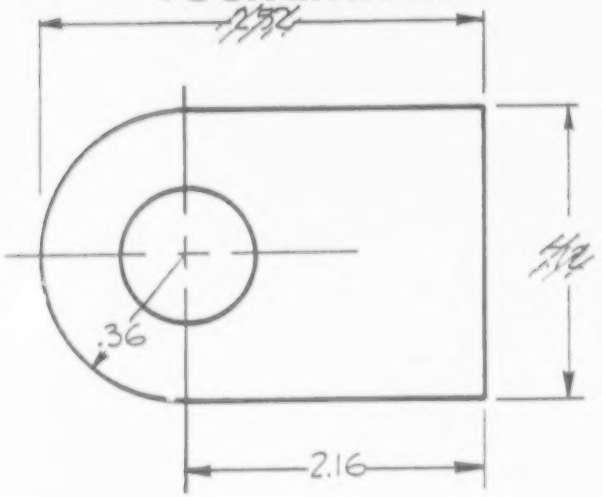


OMIT 1.34 DIMENSION

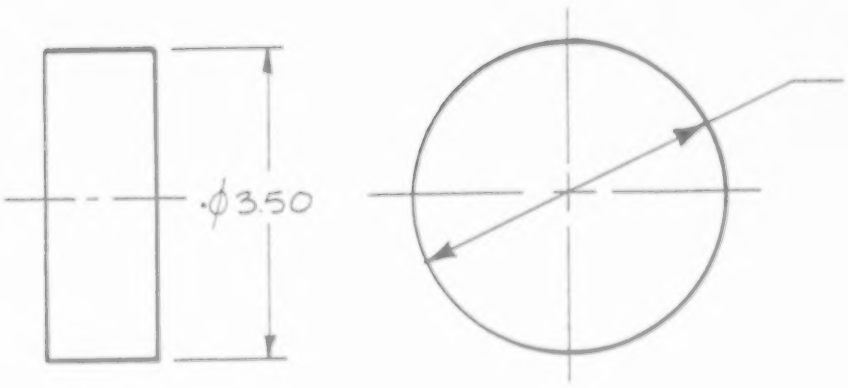


OMIT THE .50 DIMENSIONS AND THE .81 DIMENSION

Superfluous Dimensions (Continued)



Omit width and overall length



Omit diagonal diameter

DIMENSION PRISMS AND FEATURE LOCATIONS

Premise: Prisms can be dimensioned by using the following procedure.

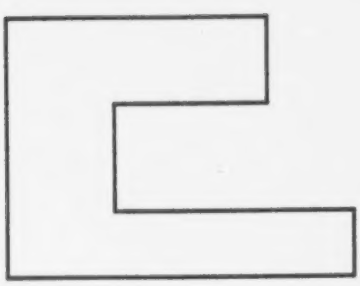
1. Decide which dimensions will be required
2. Decide which view would best show the dimensions required
3. Add dimension and extension lines as needed
4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

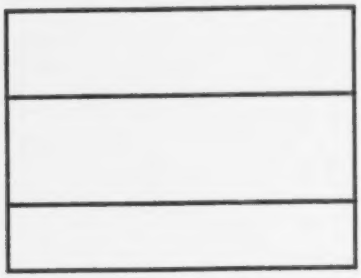
Directions: Measure then dimension the following objects using correct dimensioning procedures.

Problem A:

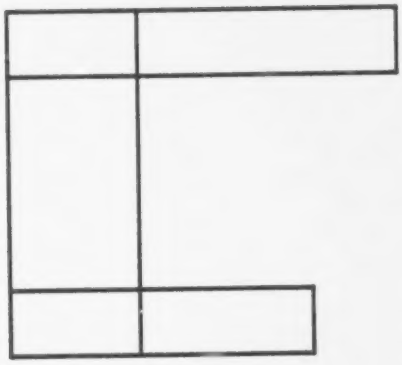
Problem B:

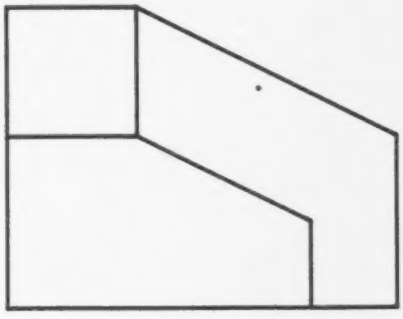
Problem C:

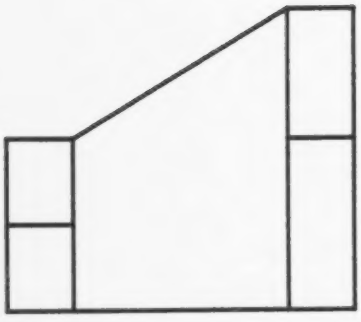




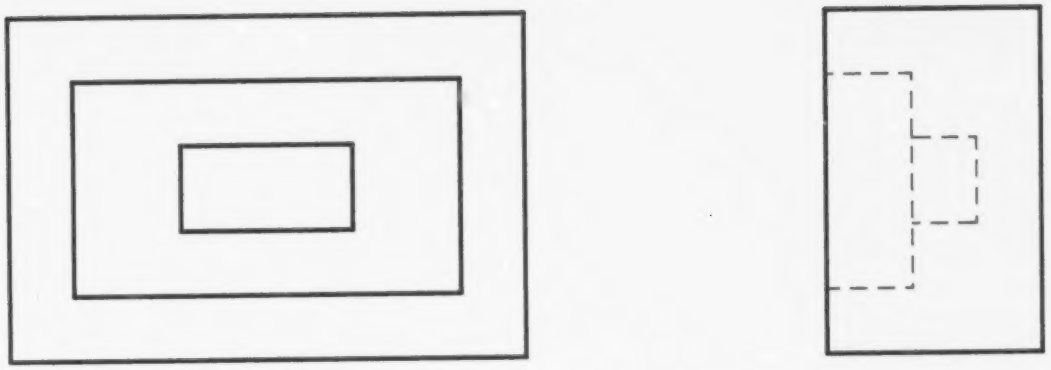
Problem D:



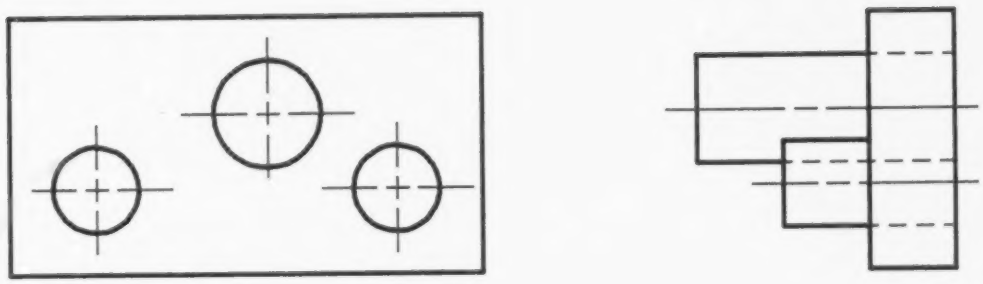




Problem E:



Problem F:



DIMENSION ANGLES

Premise: Angles can be dimensioned by using the following procedure.

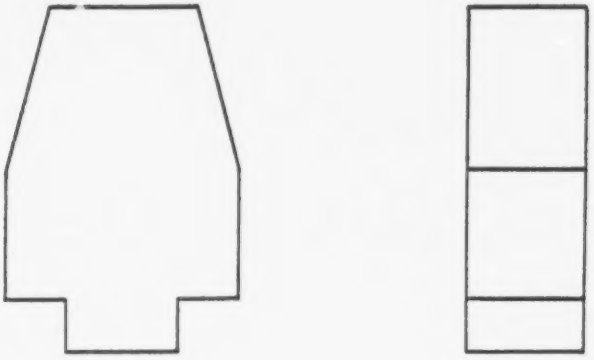
1. Decide which dimensions will be required
2. Add dimension and extension lines as needed
3. Add circular dimension lines if needed

   NOTE: Use vertex of angle for compass center; circle template is not recommended for this purpose

4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

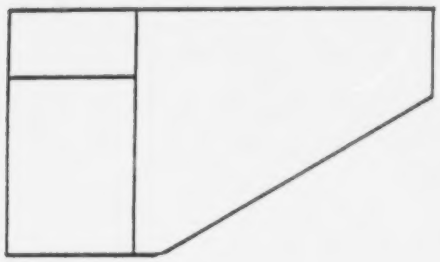
Directions: Measure then dimension the following objects using correct dimensioning procedures. Pay particular attention to dimensioning the angles.

Problem A:

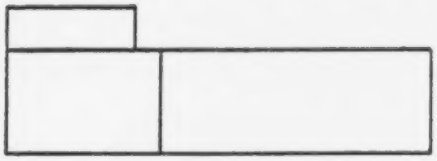


Directions: Measure then dimension the following objects using correct dimensioning procedures. Add ALL necessary dimensions to describe the object. (Express dimensions in metric units.)

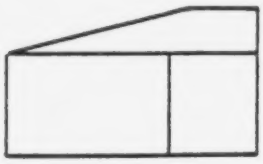
Problem B:



Top



Front

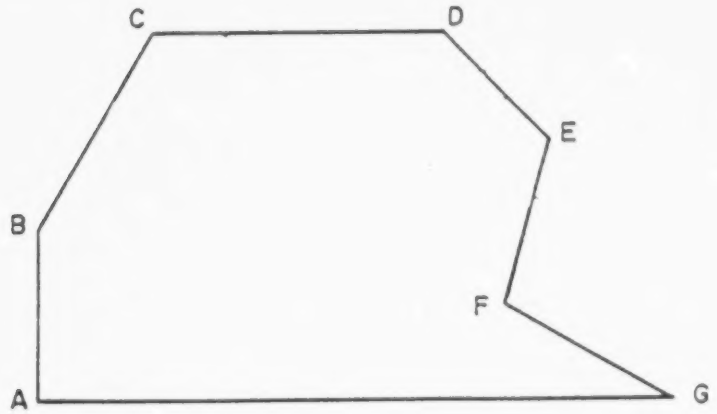


Side

METRIC

Directions: Measure and dimension all inside angles in degrees and minutes.

Problem C: Scale 1" - 100'



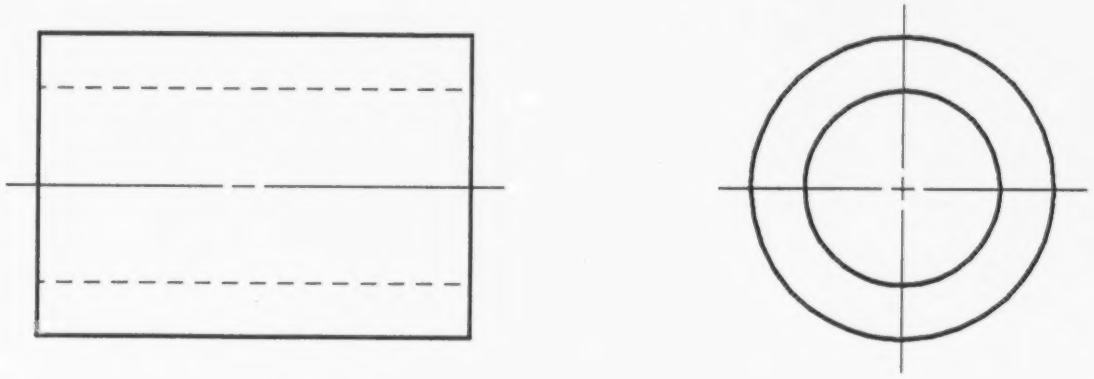
DIMENSION CYLINDRICAL OBJECTS

Premise: Cylindrical objects can be correctly dimensioned by using the following procedure.

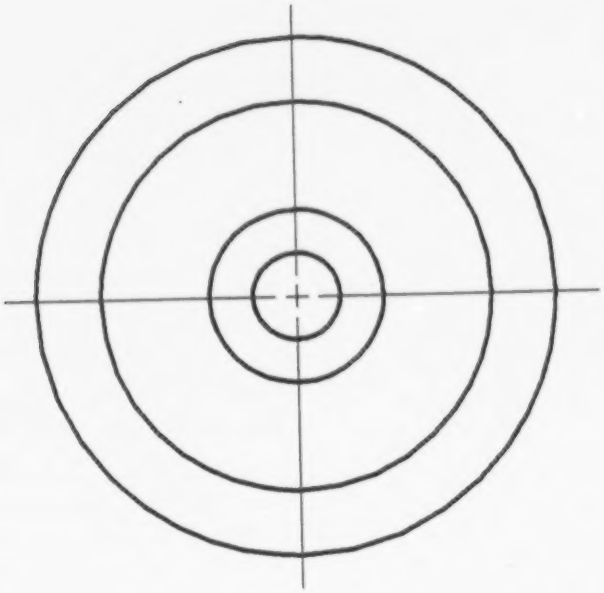
1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

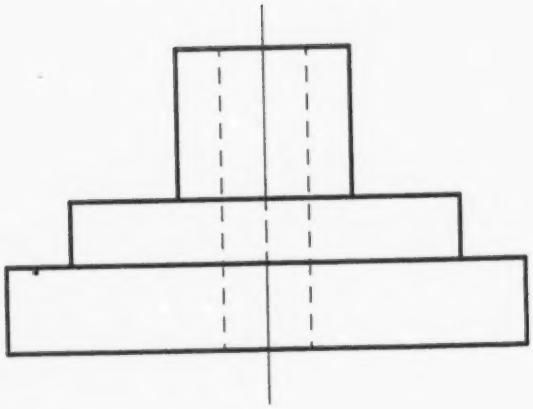
Directions: Measure and then dimension the following object using correct dimensioning procedures.

Problem A:



Problem B:





DIMENSION SPHERICAL OBJECTS

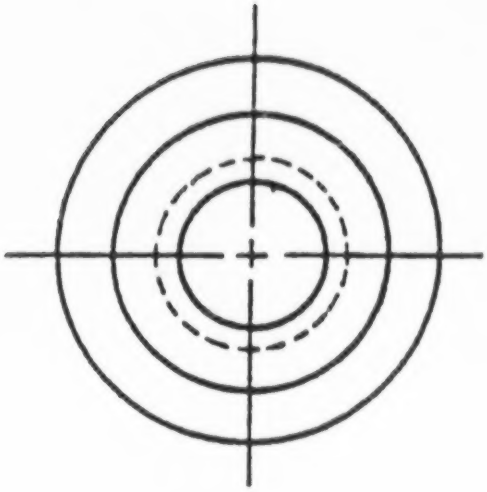
Premise: Spherical objects can be correctly dimensioned by using the following procedure.

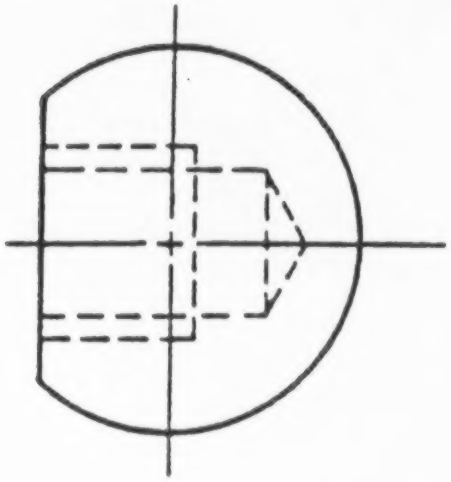
1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Measure and dimension the following objects using correct dimensioning procedures.

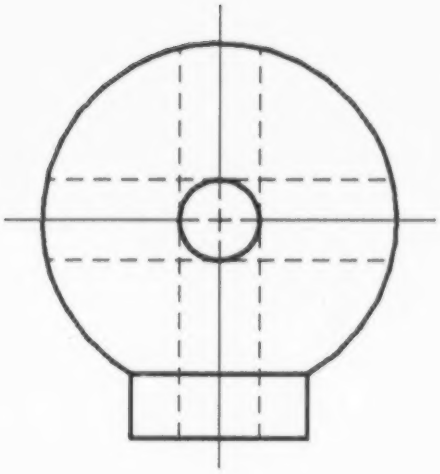
Problem A:

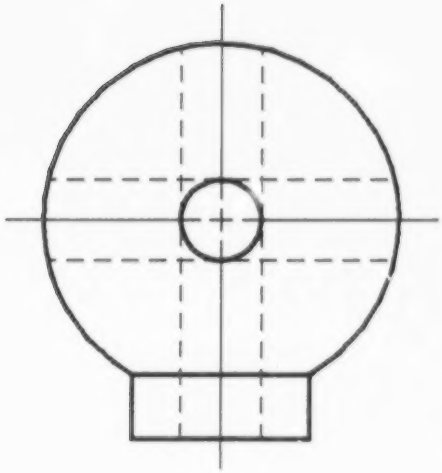
Problem B:

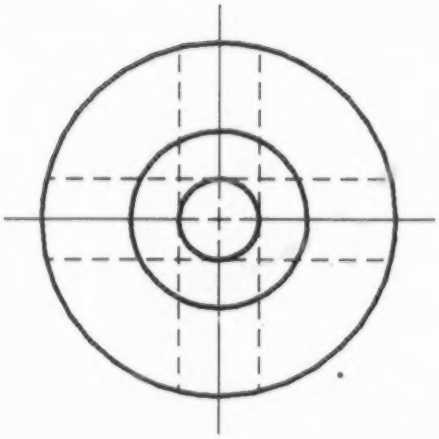




Problem C:







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DIMENSION PYRAMIDS AND CONES

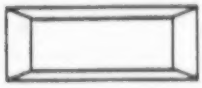
Premise: Pyramids and cones can be correctly dimensioned by using the procedures that follow.

1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

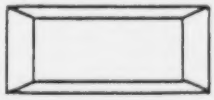
Directions: Measure and then dimension the following objects using correct dimensioning procedures.

Problem A: Pyramids

1. Dimensions of base in rectangular view and height in the other view



2. Dimensions of base in square view and center point in rectangular view



Problem B: Cones

1. Diameter and height

2. Diameter and angle

3. Two diameters and height

4. Large end diameter height and taper

DIMENSION ARCS

Premise: Arcs can be dimensioned by using the following procedure.

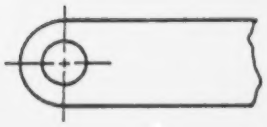
1. Determine if the arcs are located by their tangent points or require locations by their center points
2. Determine best location for leader line
3. Draw in leader line and add arrowhead
4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

Directions: Measure then dimension the following arcs and radii using correct dimensioning procedures.

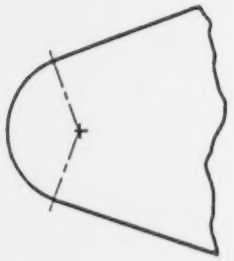
Problem A:

Problem B:

Problem C:

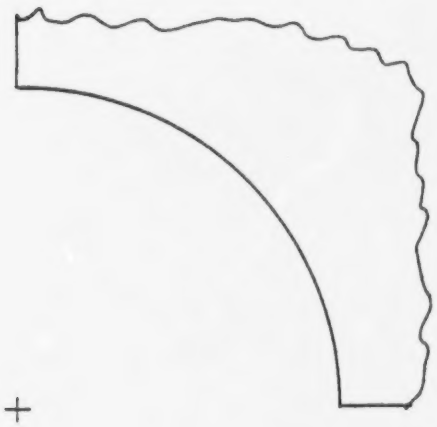


Problem D:

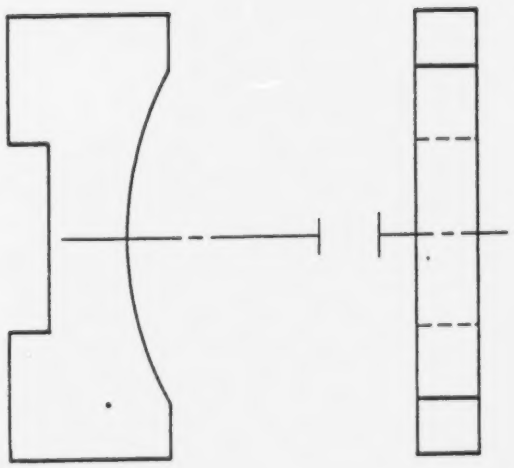


Problem E: 20" radius

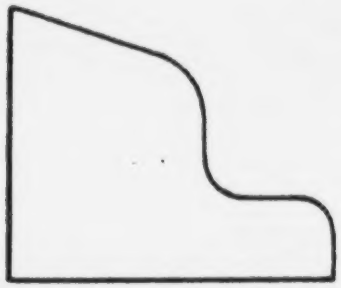
Problem F:



Problem G:



Problem H:



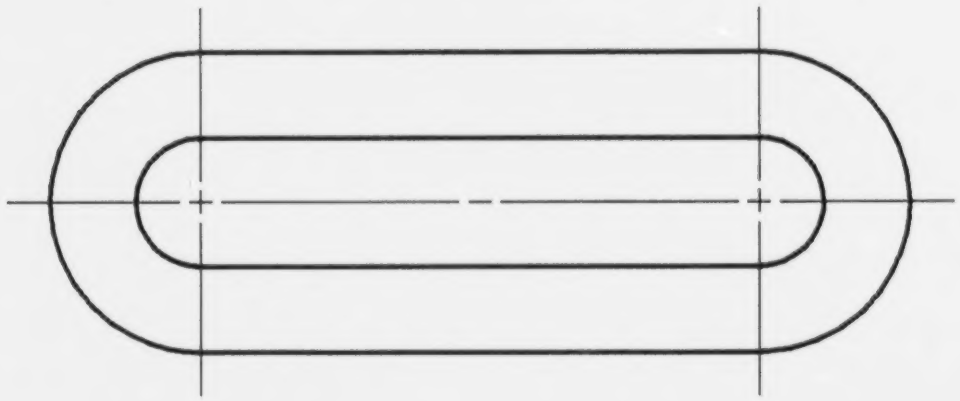
DIMENSION ROUNDED END SHAPES

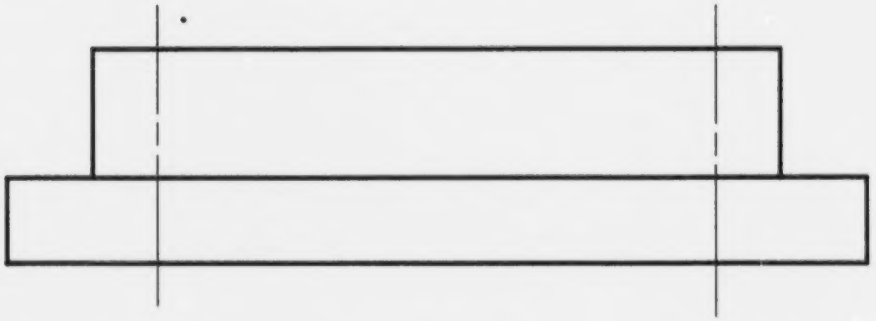
Premise: Angles can be dimensioned by using the following procedure.

1. Decide which dimensions will be required
2. Add dimension and extension lines as needed
3. Add leaders where required
4. Add guidelines for lettering
5. Letter dimension figures
6. Add arrowheads

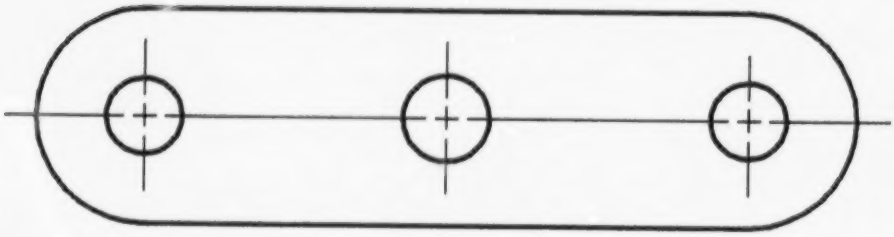
Directions: Measure then dimension the following objects using correct dimensioning procedure.

Problem A:

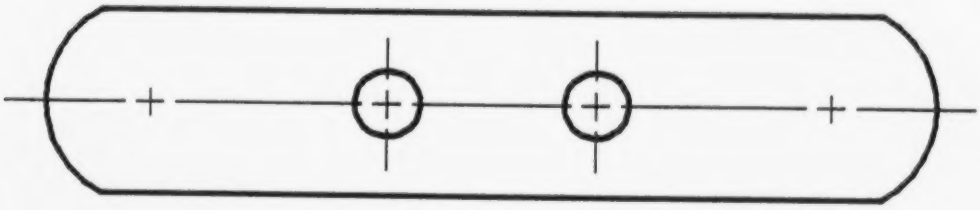




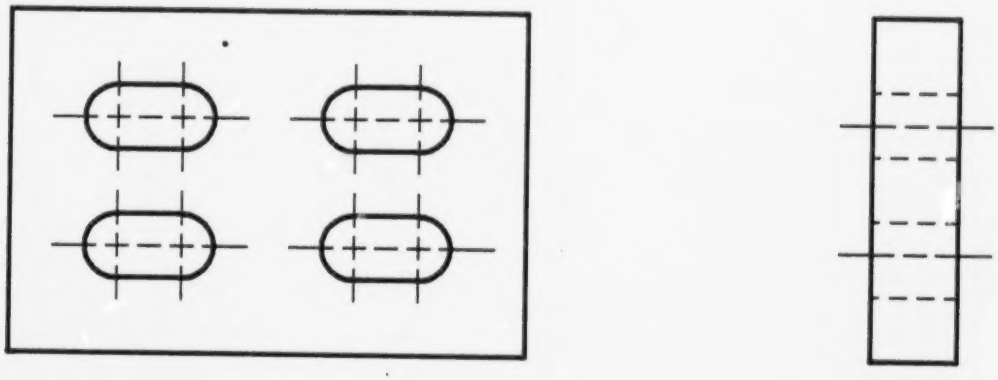
Problem B:



Problem C:



Problem D:



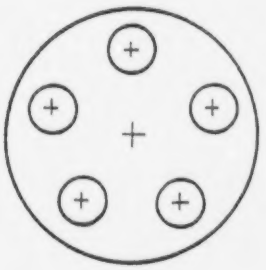
DIMENSION FEATURES ON A CIRCULAR CENTER LINE

Premise: Features on a circular center line can be correctly dimensioned by using the following procedure.

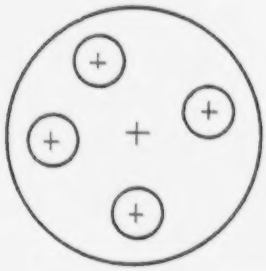
1. Determine if the objects have all center points given or if they can be located through geometric construction
2. Decide what dimensions have to be added
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Measure and then dimension the following objects using correct dimensioning procedures. (Don't forget center lines.)

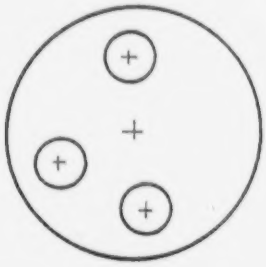
Problem A: Holes equally spaced



Problem B: Holes unequally spaced; indicate angular measurements



Problem C: Holes unequally spaced; use coordinate dimensions



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DIMENSION CURVES

Premise: Curves can be correctly dimensioned by using the following procedure.

1. Determine if the curves have all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Add arrowheads

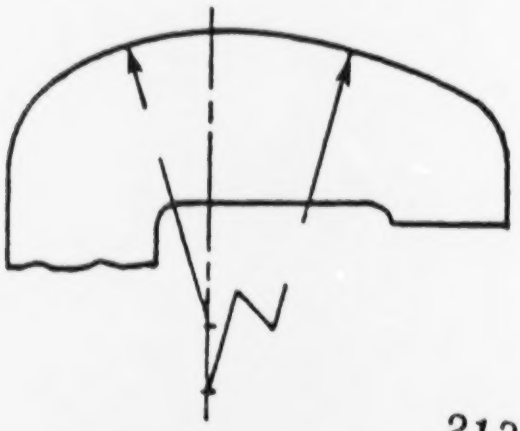
Directions: Measure and fill in the dimension by using the following procedure.

1. Determine if the curves have all center points given of if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

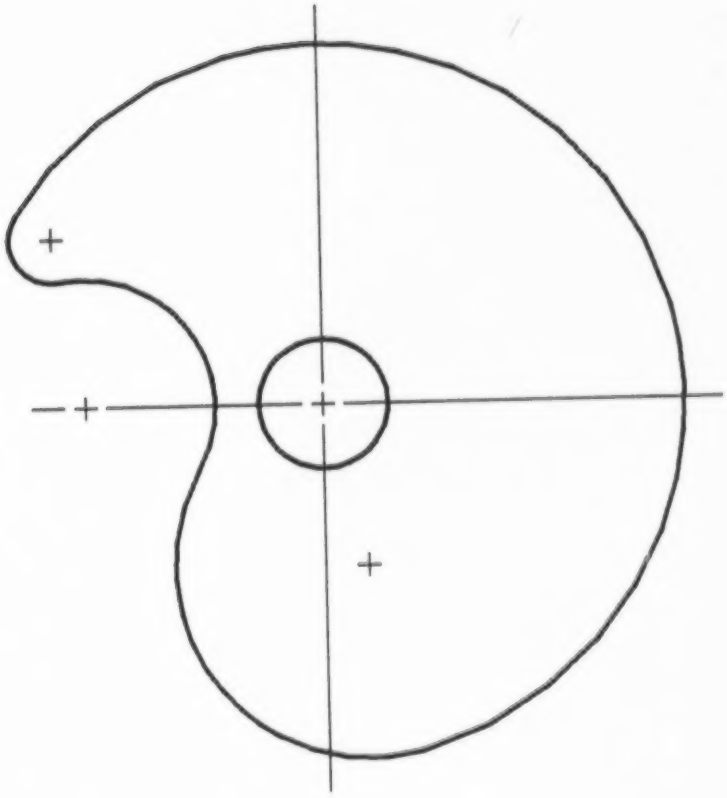
Directions: Measure and fill in the dimensions for the arcs indicated using correct dimensioning procedure.

NOTE: The large arc has a radius of 3 3/8"

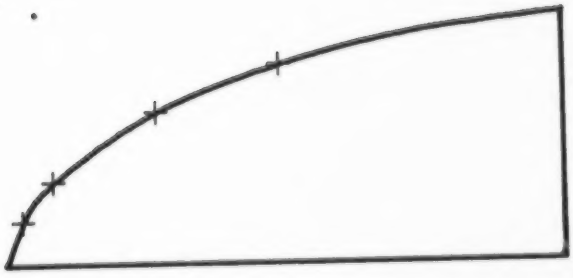
Problem A:



Problem B:



Problem C:

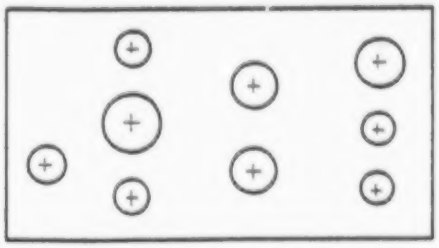


DIMENSION AND OBJECT USING A RECTANGULAR COORDINATE SYSTEM

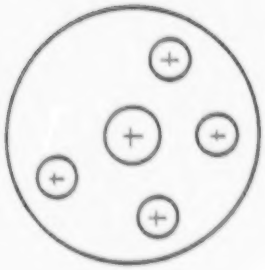
Premise: An object can be correctly dimensioned using a rectangular coordinate system by using the following procedure.

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Measure and then dimension the following objects using rectangular coordinate dimensioning procedure.



Problem B:



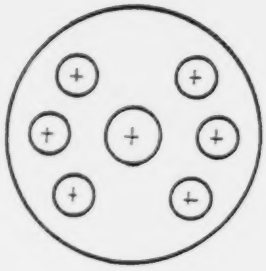
DIMENSION AN OBJECT USING A POLAR COORDINATE SYSTEM

Premise: An object can be correctly dimensioned using a polar coordinate system by using the following procedure.

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Measure and then dimension the following object using polar coordinate dimensioning procedures.

Problem:



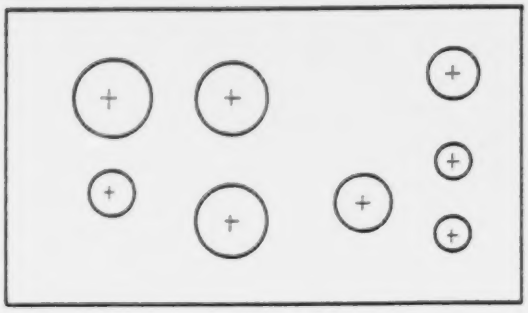
DIMENSION AN OBJECT USING A TABULAR COORDINATE SYSTEM

Premise: An object can be correctly dimensioned using a tabular coordinate system by using the following procedure.

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Measure and then dimension the following object using tabular coordinate dimensioning procedures and properly make a chart.

Problem:



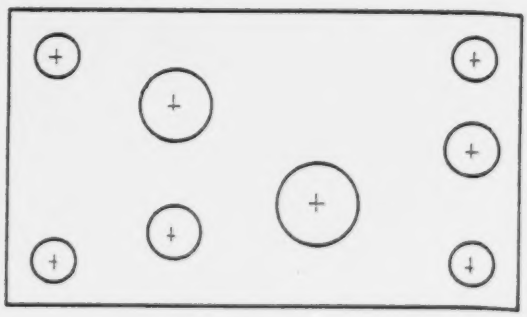
DIMENSION AN OBJECT USING AN ORDINATE DIMENSIONING SYSTEM

Premise: An object can be correctly dimensioned using an ordinate dimensioning system by using the following procedure.

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

Directions: Dimension the following object using ordinate dimensioning procedures.

Problem:



DIMENSION AN OBJECT USING PROPER DIMENSIONING PROCEDURES TO COMPLETELY DESCRIBE THE OBJECT

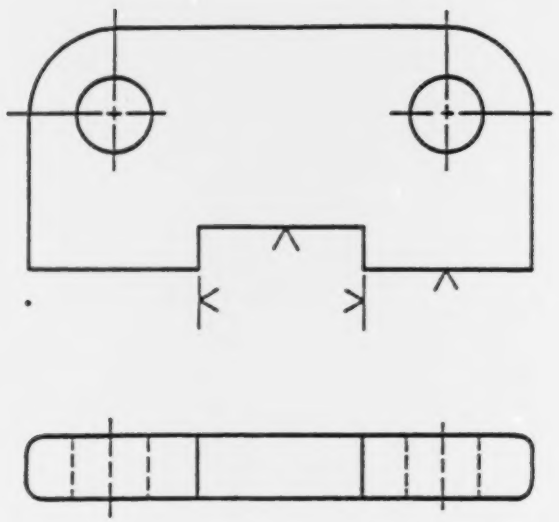
Premise: An object can be correctly dimensioned and completely described by using the procedure in the following example.

Example:

1. Determine if the object has all center points given or if they can be located through geometric construction
2. Decide which dimensions are required
3. Add dimension and extension lines as needed
4. Add leaders as needed
5. Add guidelines for lettering
6. Letter dimension figures
7. Add arrowheads

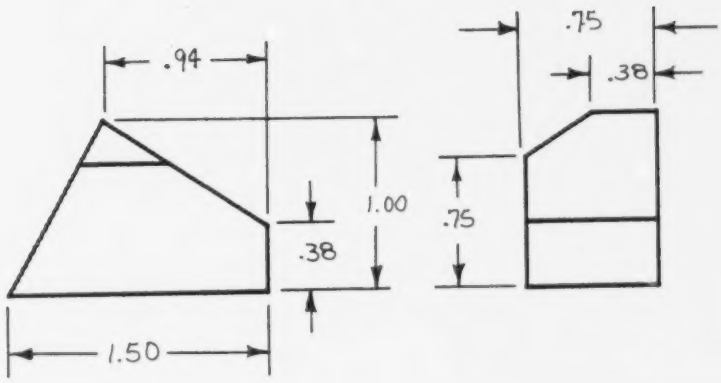
Directions: Dimension the following object using correct dimensioning procedures.

Problem: A

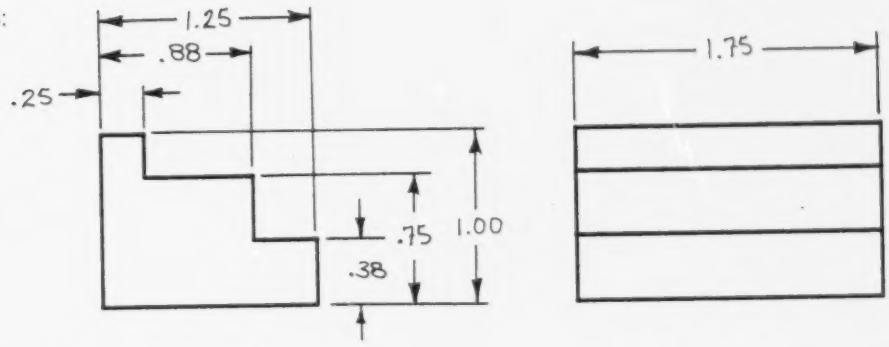


ANSWERS TO ASSIGNMENT SHEETS

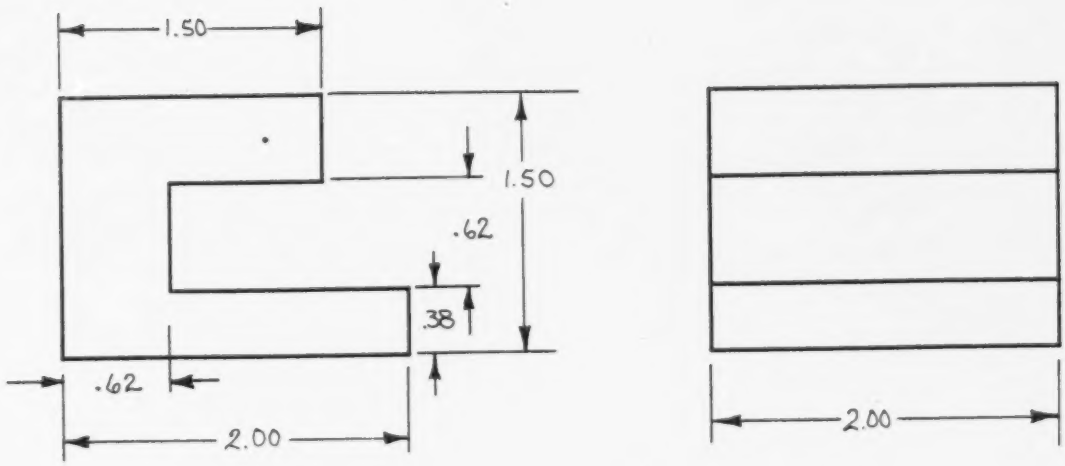
AS 1.1
A:



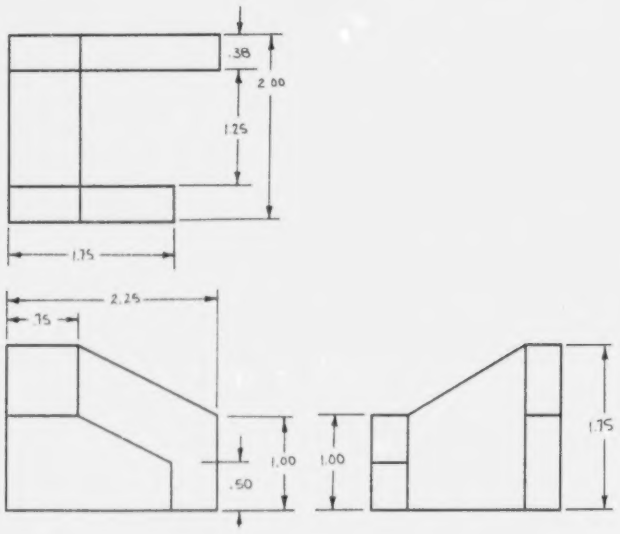
B:



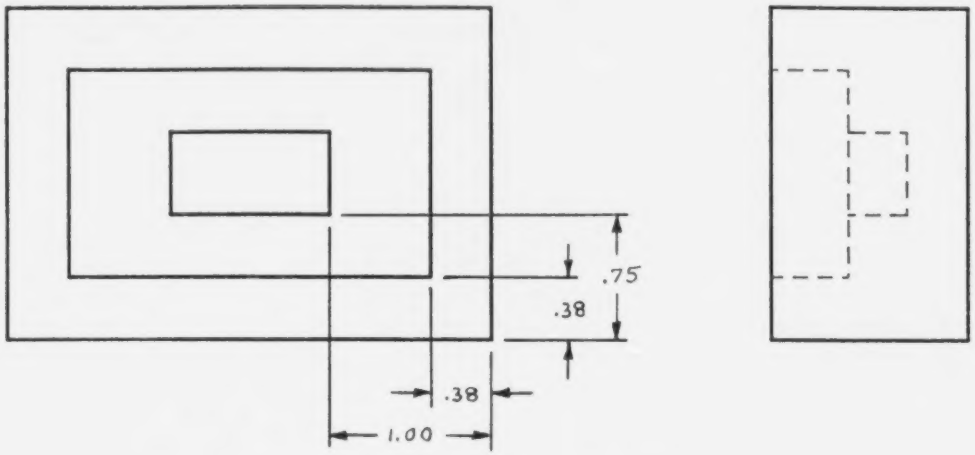
C:



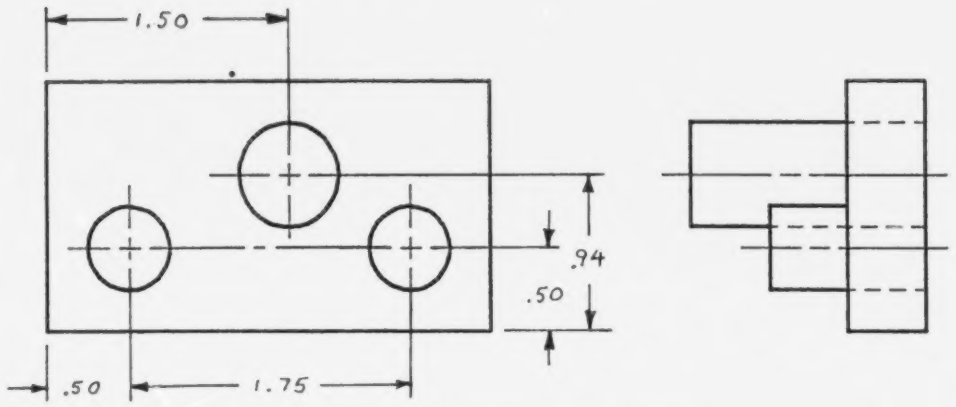
D:



E:

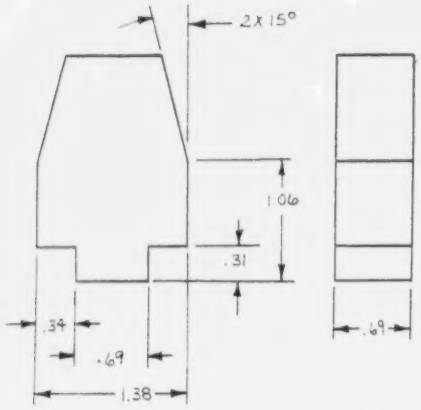


F:

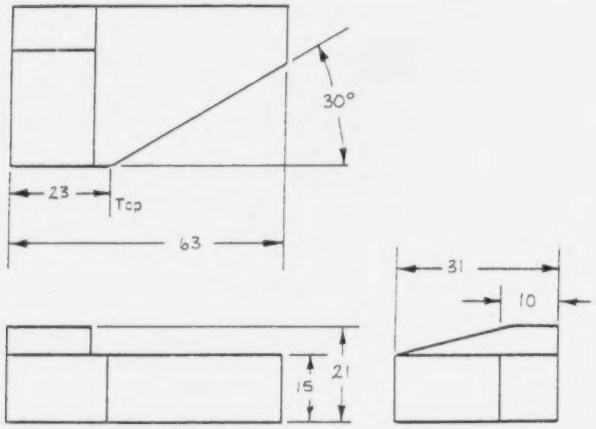


AS 1.2

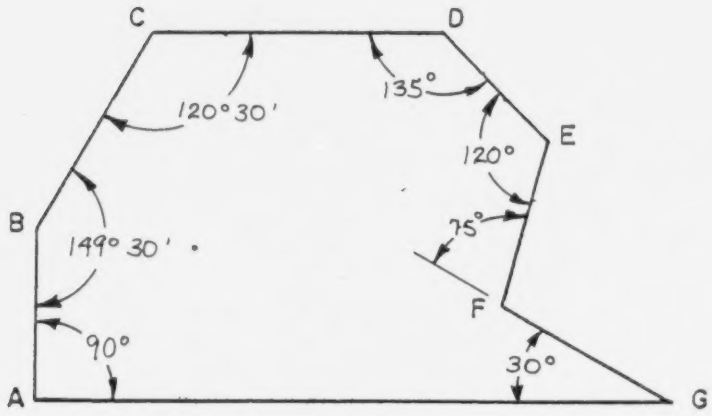
A:


2 X 15°
1.06
.31
.34
.69
.69
1.38

B:

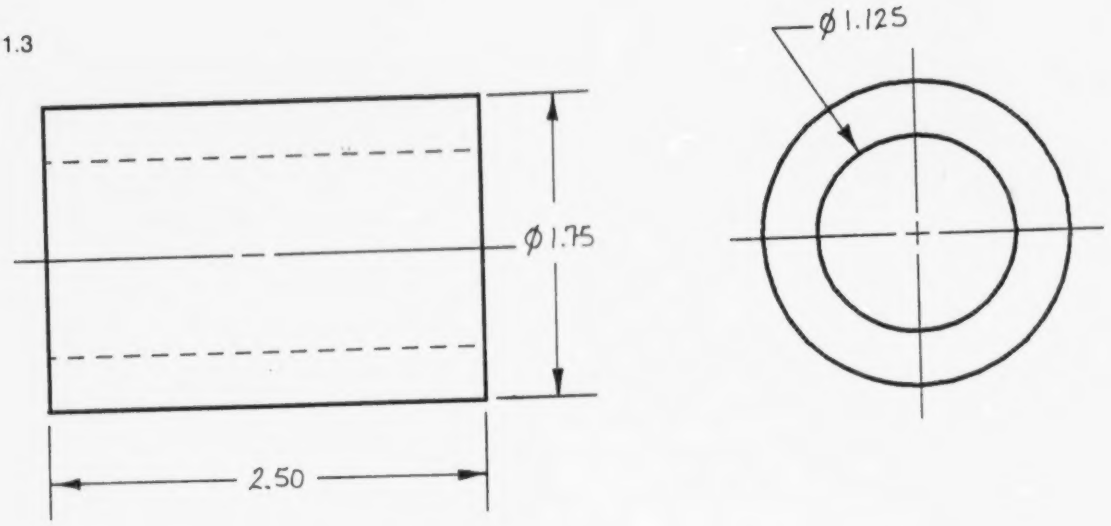

30°
23
Tap
63
31
10
15
21

C:

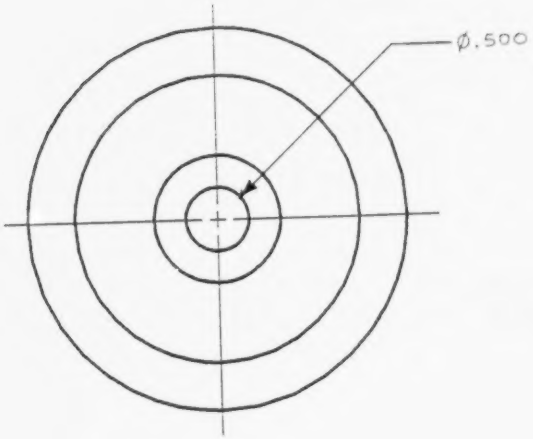

C
D
120° 30'
135°
E
120°
B
149° 30'
75°
F
90°
30°
A
G

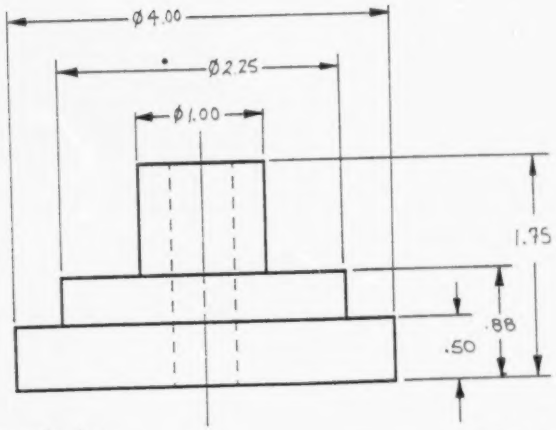
AS 1.3

A:



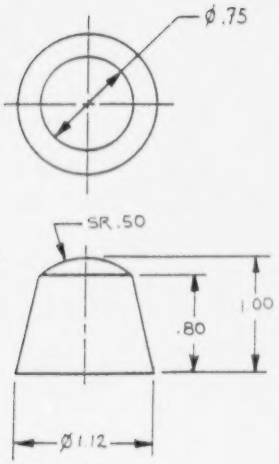
B:



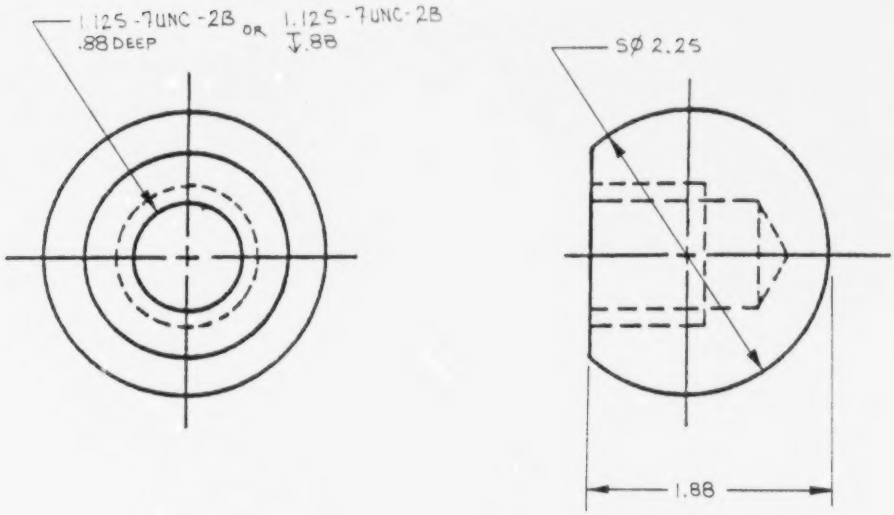


AS 1.4

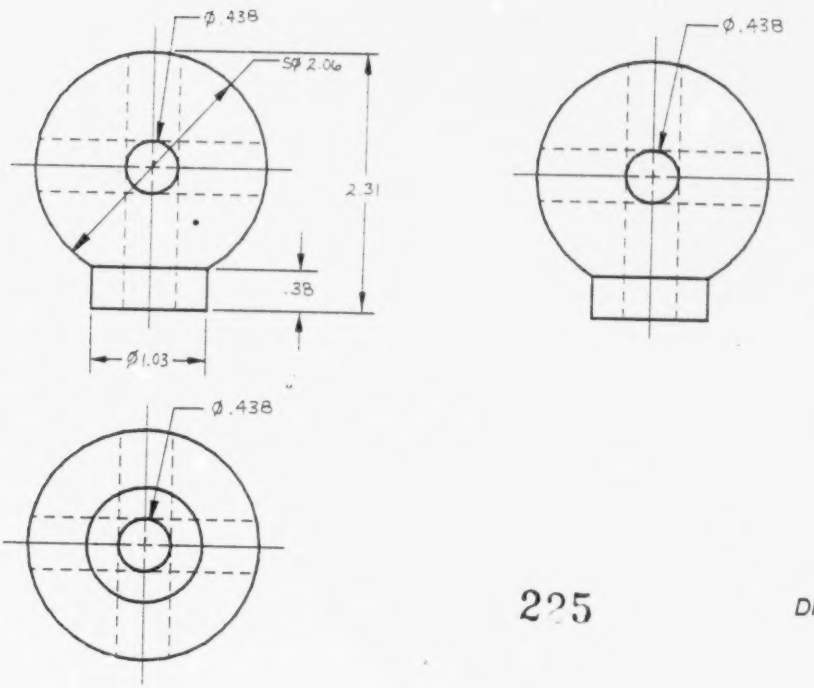
A:


Ø.75
SR.50
1.00
.80
Ø1.12

B:

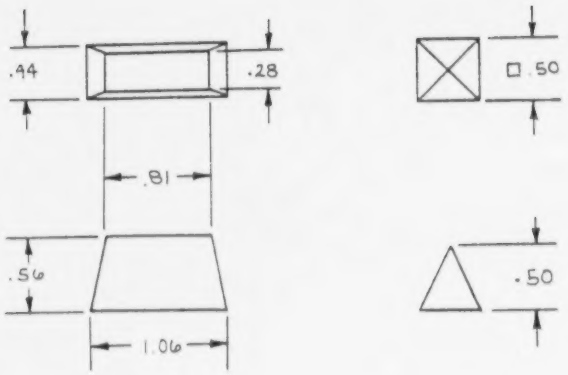

1.125-7UNC-2B
.88 DEEP
OR
1.125-7UNC-2B
↧.88
SØ 2.25
1.88

C:

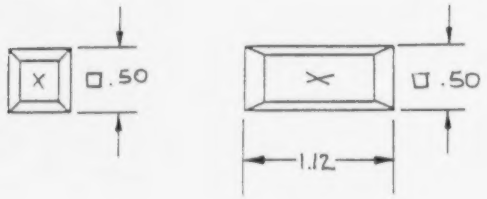

Ø.438
SØ 2.06
2.31
.38
Ø1.03
Ø.438
Ø.438

AS 1.5

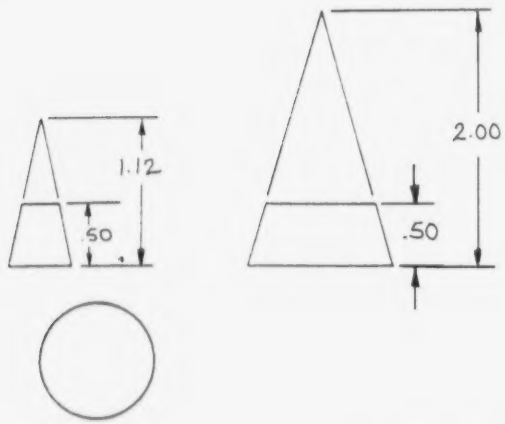
A: 1



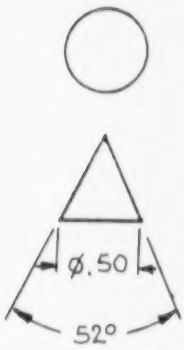
A: 2



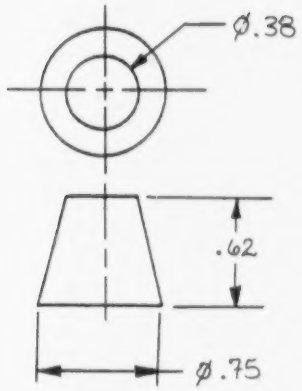
B: 1



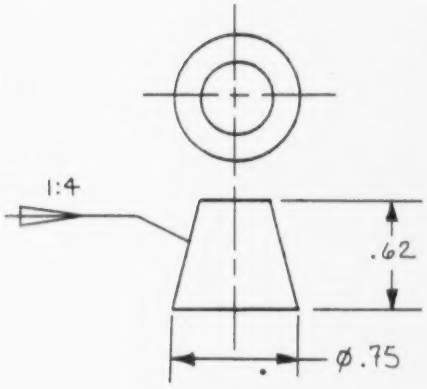
B: 2



B: 3

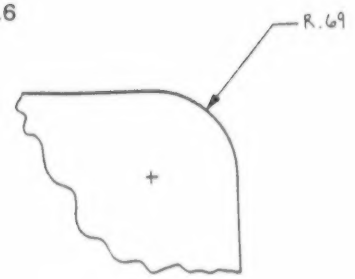


B: 4

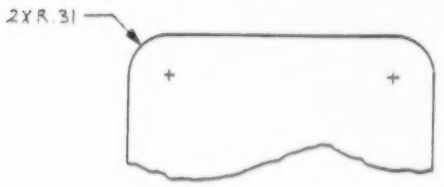


AS 1.6

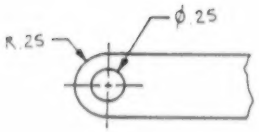
A:



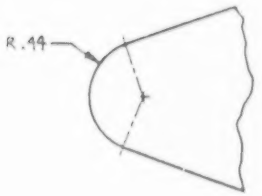
B:



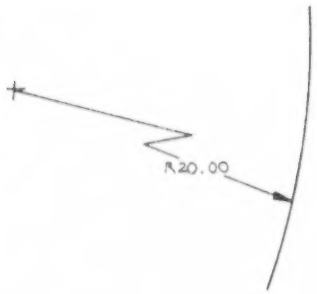
C:



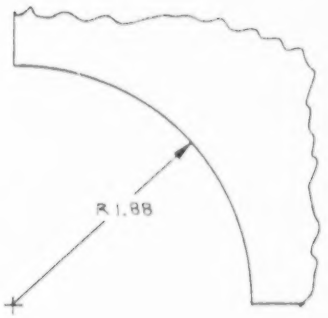
D:



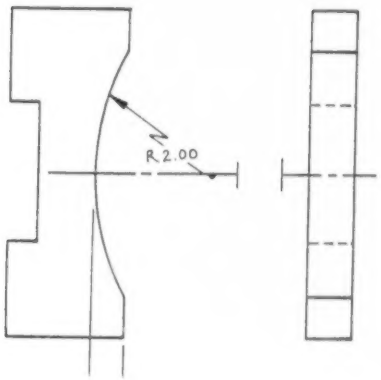
E:



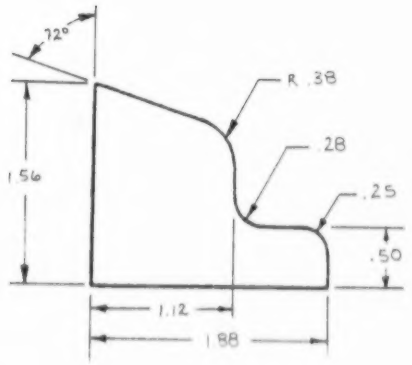
F:



G:



H:



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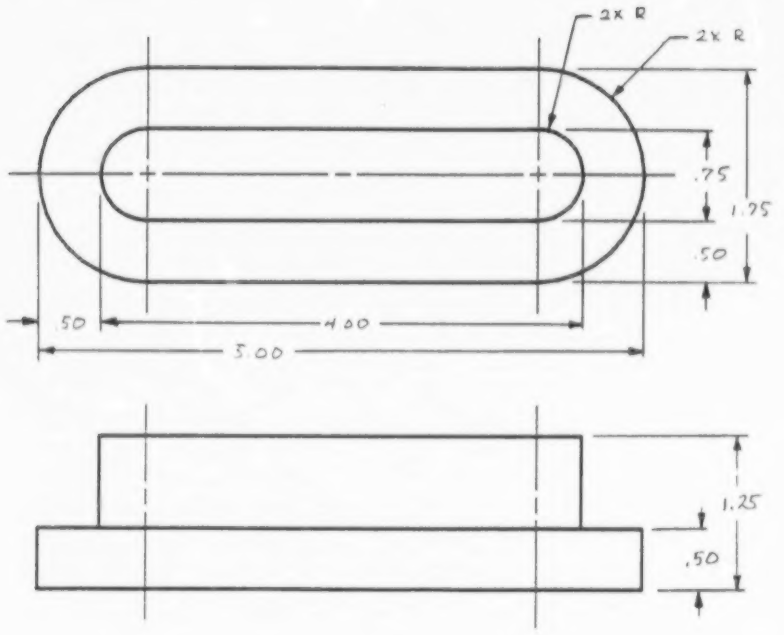
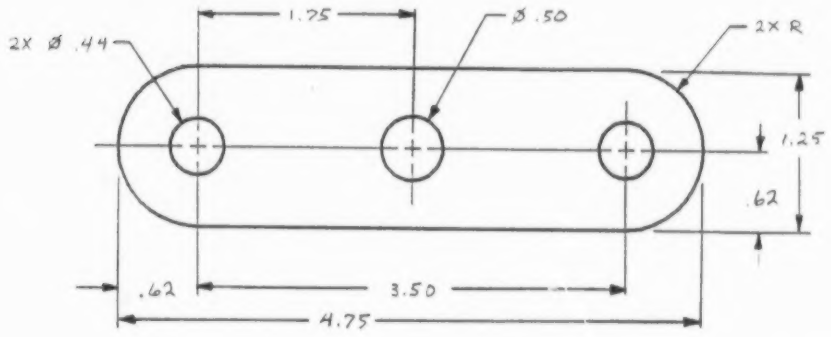
AS 1.7

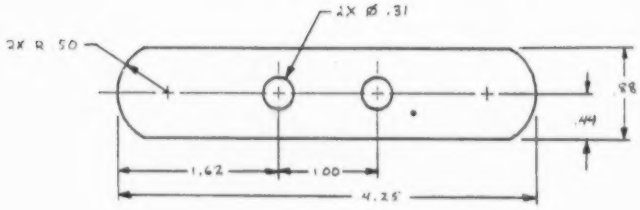
A:


2X R
2X R
.75
1.25
.50
.50
4.00
5.00
1.25
.50

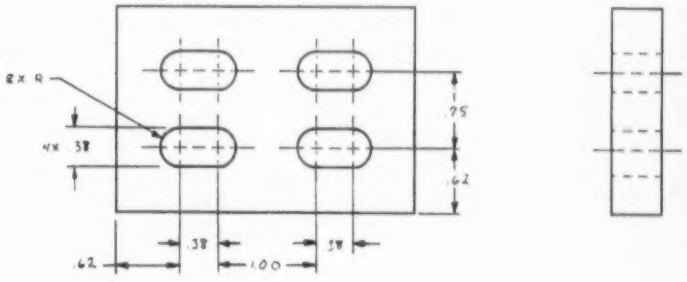
B:


1.75
Ø .50
2X Ø .44
2X R
1.25
.62
.62
3.50
4.75

C.

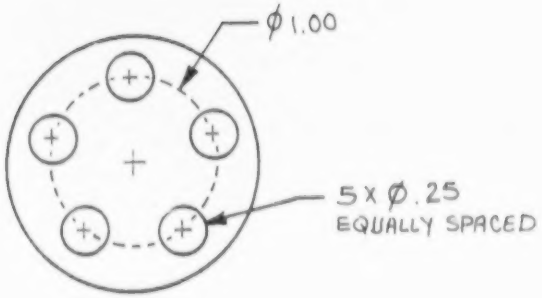

2X Ø .31
2X R .50
.88
.44
1.62
1.00
4.25

D.

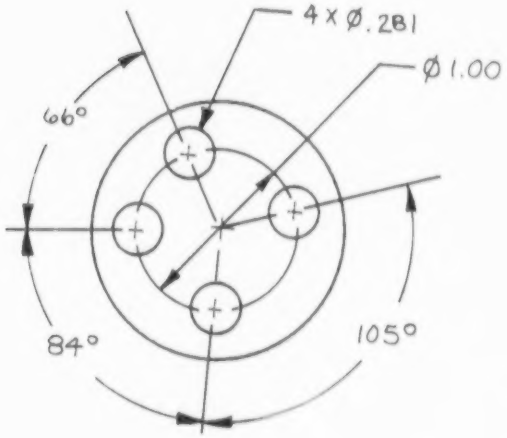

8X R
4X .38
.75
.62
.62
.38
.38
1.00

AS 1.8

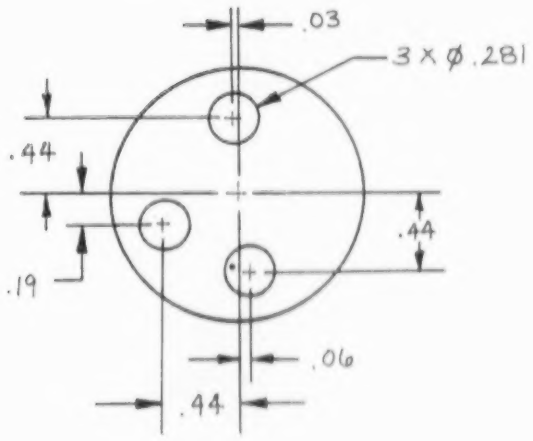
A:


Ø1.00
5 x Ø.25
EQUALLY SPACED

B:

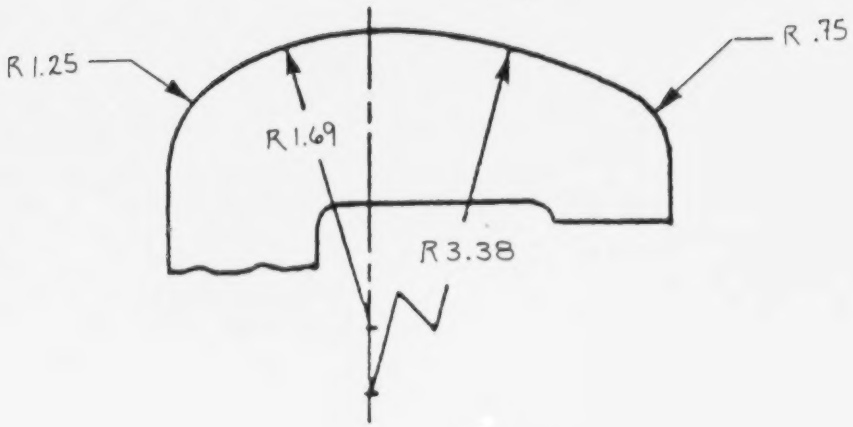

4 x Ø.281
Ø1.00
66°
84°
105°

C:

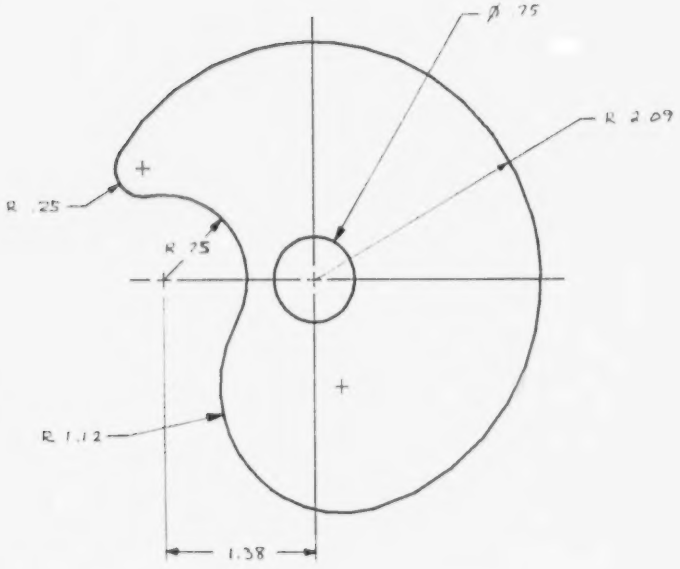

.03
3 x Ø.281
.44
.44
.19
.06
.44

AS 1.9

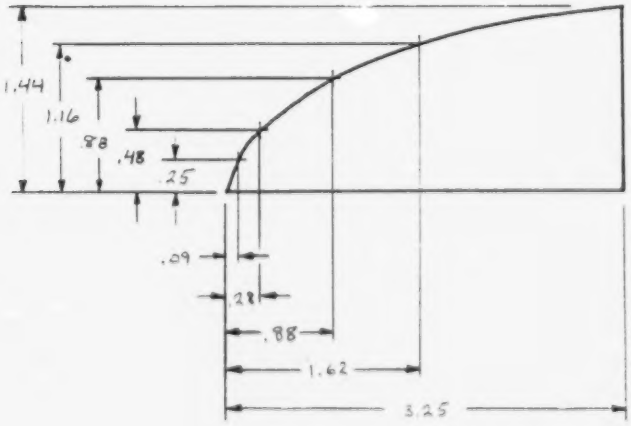
A:


R 1.25
R 1.69
R 3.38
R .75

B:

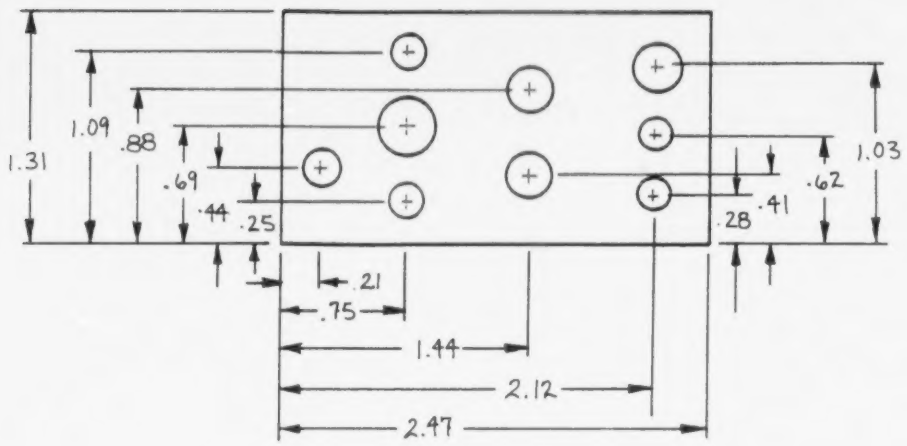

Ø .75
R 2.09
R .25
R .75
R 1.12
1.38

C:

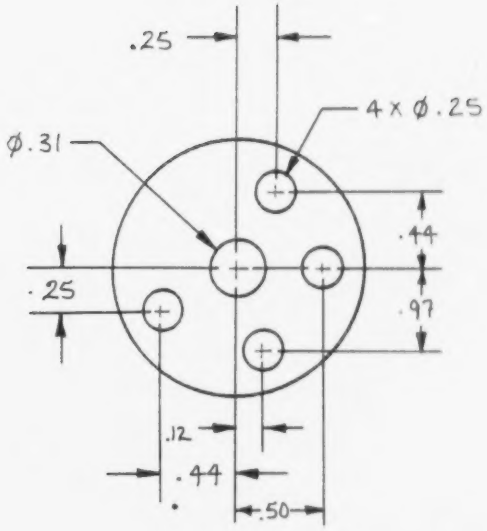

1.44
1.16
.88
.48
.25
.09
.28
.88
1.62
3.25

AS 1.10

A:

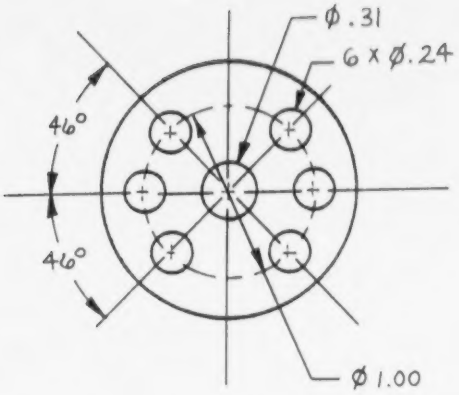

1.31
1.09
.88
.69
.44
.25
.21
.75
1.44
2.12
2.47
1.03
.62
.41
.28

B:

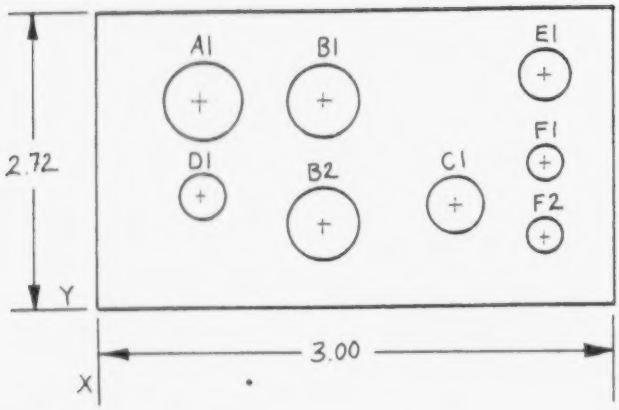

.25
4 x Ø.25
Ø.31
.44
.25
.97
.12
.44
.50

232

AS 1.11

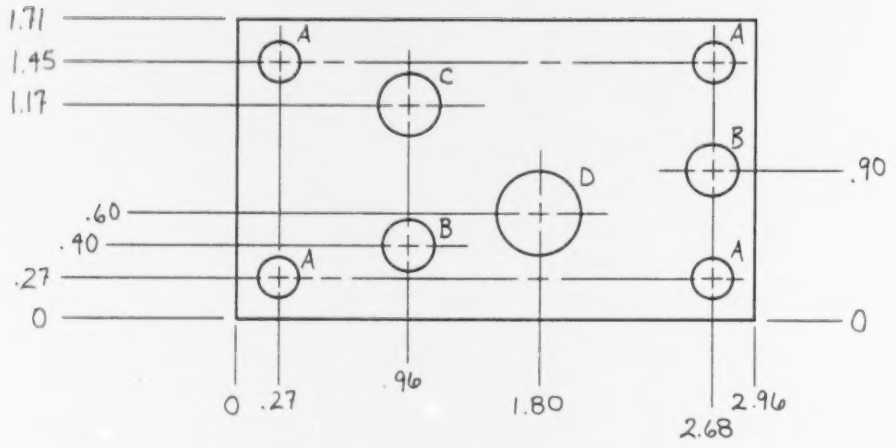


AS 1.12



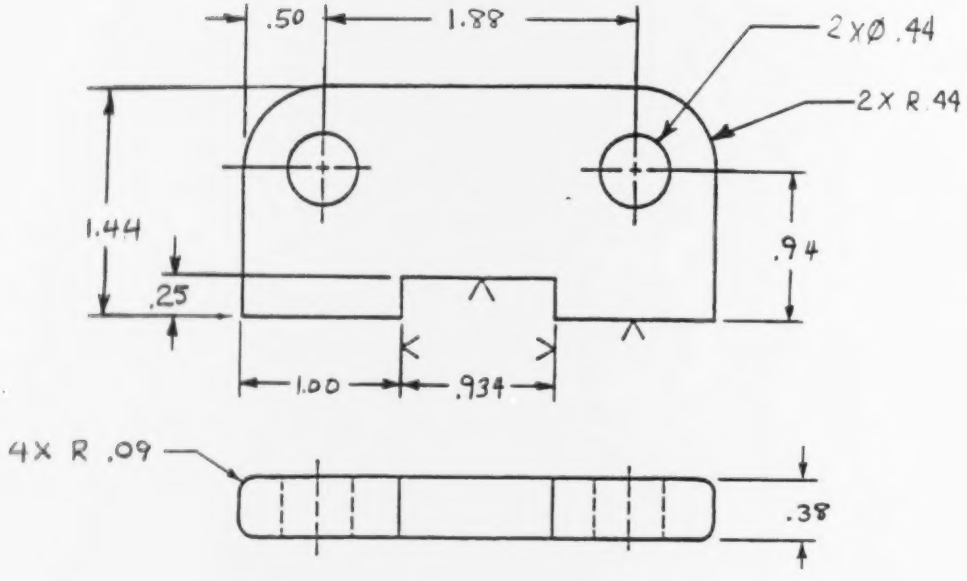
HOLE	Ø	X	Y	Z	NOTE
A1	.80	1.47	.59	THRU	-
B1	.70	1.19	.28	THRU	-
B2		.25	.28	THRU	-
C1	.50	.31	2.08	THRU	-
D1	.30	.66	.59	THRU	-
E1	.40	.38	2.56	THRU	-
F1	.20	.38	2.56	THRU	-
F2		.38	2.56	THRU	-

AS 1.13



SIZE SYMBOL	A	B	C	D
HOLE 0	.25	.31	.43	.47

AS 1.14



MODULE: ORTHOGRAPHIC DRAWINGS AND DIMENSIONING

UNIT II: DIMENSIONING AND TOLERANCING

UNIT TEST

Match the terms on the right with their correct definitions on the left.

____	1.	Exceeding what is sufficient or necessary	a. Chamfer
____	2.	Points, lines, or other geometric shapes assumed to be exact from which the location or geometric features of a part may be established	b. Tabular
____	3.	Set up in rows and columns, by means of a table	c. Superfluous
____	4.	A dimension used for information purposes only; it does not govern production or inspection operations	d. Actual size
____	5.	Measured size of a complete object	e. Datum
____	6.	A gradual decrease or change of diameter from one end to the other	ab. Bevel
____	7.	A slanted flat surface not at 90° to another surface	ac. Reference dimension
____	8.	A slight bevel removed from an edge	ad. Taper
____	9.	A hole not drilled all the way through	ae. Boss
____	10.	A raised flat, cylindrical surface providing a flat surface for bolts	bc. Radial
____	11.	Moving along a radius	bd. Nominal
____	12.	Designated or theoretical size that may vary from the actual	be. Blind hole

Distinguish between size description and shape description by placing an "a" next to the size description and a "b" next to the shape description.

_____ 13. The views that illustrate the shape of an object

_____ 14. The notes and dimensions that tell the size of an object

Differentiate between the types of dimension in the accompanying illustration by placing an "a" next to the location dimensions and a "b" next to the size dimensions.

_____ 15. Dimension A

_____ 16. Dimension B

_____ 17. Dimension C

_____ 18. Dimension D

_____ 19. Dimension E

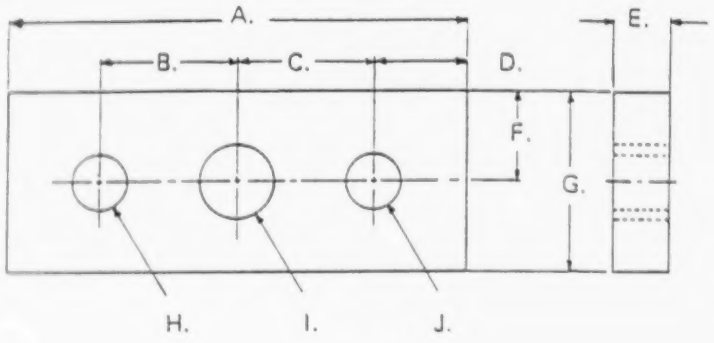
_____ 20. Dimension F

_____ 21. Dimension G

_____ 22. Dimension H

_____ 23. Dimension I

_____ 24. Dimension J



Choose the correct system of placing dimensions for each definition.

____ 25. All dimension figures are aligned with the dimension lines so that they may be read from the bottom or from the right side of the sheet

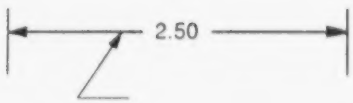
a. Unidirectional system b. Aligned system

____ 26. All dimension figures and notes are lettered horizontally on the sheet and read from the bottom of the drawing

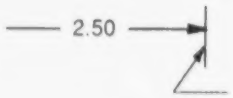
a. Unidirectional system b. Aligned system

Match the names of the four basic types of line used in dimensioning on the right with the correct lines on the left.

___ 27.



___ 28.



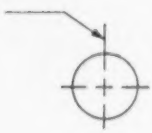
a. Extension line

b. Dimension line

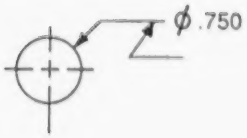
c. Leader line

d. Center line

___ 29.



___ 30.



Mark an "a" in the blanks for true statements concerning rules for lines used in dimensioning. Mark a "b" for false statements.

___ 31. Extension lines start or stop 1/16" away from visible lines and are extended approximately 1/8" beyond dimension lines

___ 32. Extension lines may never cross each other

___ 33. Extension lines are classified as thin lines

___ 34. Extension lines may cross dimension lines

___ 35. Center lines may be used as dimension lines

___ 36. Dimension lines are classified as thick lines

___ 37. Dimension lines are broken to allow space for the dimension

___ 38. Dimension lines are drawn as arcs to show angular measurement

___ 39. Leaders are usually drawn vertical or horizontal

___ 40. The leader arrowhead touches the arc and points toward the center point

___ 41. A leader should always point to the middle of a note

Mark an "a" for true statements concerning rules for dimensional figures. Mark a "b" for false statements.

____ 42. All lettering, letters, and numerals must be perfectly legible

____ 43. Standard height of numerals is 1"

____ 44. Fractions are four times the height of whole numbers

____ 45. Inch marks (") should always be used

____ 46. The fraction bar is always drawn at an angle on a view

____ 47. The numerator and denominator of a fraction should touch the fraction bar

____ 48. Never letter a dimension figure over any line on the drawing; break the line if necessary

____ 49. Make all decimal points bold

____ 50. In a group of parallel dimension lines, the numerals should be stacked one above the other

Mark true statements concerning rules for placement of dimensions by placing an "a" in the appropriate blanks. Mark a "b" for false statements.

____ 51. Each dimension should be given clearly so that it can be interpreted in only one way

____ 52. Dimensions may be duplicated at any time

____ 53. Dimensions should be given between points or surfaces that have a functional relation to each other or that control the location of mating parts

____ 54. Dimensions should be given to finished surfaces or important center lines in preference to rough surfaces wherever possible

____ 55. Dimensions do not need to be complete enough for a machinist

____ 56. Dimensions should be drawn to hidden lines wherever possible

____ 57. Dimensions applying to two adjacent views should be placed between views unless clearness is promoted by placing some of them outside

____ 58. Do not expect the worker to assume that a feature is centered (as a hole on a plate), but give a location dimension from one side

____ 59. Horizontal and vertical center lines should not be used as extension lines for dimensions

Mark true statements concerning rules for notations by placing an "a" in the appropriate blanks. Mark a "b" for false statements.

____ 60. Notes are always placed parallel to the side of the drawing

____ 61. Notes should be brief and clear and contain only pertinent data

____ 62. Notes should be spaced far enough from the views not to crowd, but still close enough to eliminate the need for a long leader

____ 63. Notes should always be composed so that the various shop operations are listed in the order in which they should be performed

____ 64. Use lower case letters for all notes on machine drawings

____ 65. "R" precedes all radii dimensions; the center is shown by a cross and only one arrowhead is used; available space determines whether the dimension figure goes inside or outside the arc

____ 66. A circle is always dimensioned by its radius

____ 67. A diameter dimension value should be preceded by the symbol ϕ.

____ 68. Cylinders should be located by their radius

____ 69. Drill sizes are preferably expressed in fractions

____ 70. Cylinders should be located in the circular views, if possible

____ 71. Cylinders should always be located by angular dimensions where accuracy is important

____ 72. When a dimension is not to scale, it should be underscored with a bold straight line

____ 73. Decimal dimensions should be used when accuracy greater than 1" is required on a machine dimension

74. **State the purpose for a notation on a drawing.**

ANSWERS TO UNIT TEST

1. c
2. e
3. b
4. ac
5. d
6. ad
7. ab
8. a
9. be
10. ae
11. bc
12. bd
13. b
14. a
15. b
16. a
17. a
18. a
19. b
20. b
21. b
22. b
23. b
24. b
25. b
26. a
27. b
28. a
29. d
30. c
31. a
32. b
33. a
34. b
35. b
36. b
37. a
38. a
39. b
40. a
41. b
42. a
43. b
44. b
45. b
46. b
47. b
48. a
49. a
50. b
51. a
52. b
53. a
54. a
55. b
56. b
57. a
58. a
59. b
60. b
61. a
62. a
63. a
64. b
65. a
66. b
67. a
68. b
69. b
70. a
71. b
72. b
73. b
74. To provide in concisely worded statements information that cannot be given by standard dimensions.